DOCUMENT RESUME

ED 208 864 IR 009 776

TITLE Information Technology in Education: Perspectives and Potentials. Report Prepared for the Subcommittee on Science, Research and Technology of the Committee on Science and Technology, U.S. House of Representatives, Ninety-Sixth Congress, Second Session.

INSTITUTION Library of Congress, Washington, D.C. Congressional Research Service.

SPONS AGENCY Congress of the U.S., Washington, D.C. House Committee on Science and Technology.

PUB DATE Dec 80

NOTE 348p.; Serial QQQ. Pages 201-255 and 207-303 will not reproduce due to the size of type in the original document. For related document, see ED 198 816.

AVAILABLE FROM Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 (1981- 77-352-0).

EDRS PRICE MF01/PC14 Plus Postage.

DESCRIPTORS Computers; *Educational Technology; *Futures (of Society); Government Role; Hearings; *Information Science; Microcomputers; *Outcomes of Education; *Policy Formation; Research Needs; *Technological Advancement; Telecommunications; Video Equipment

IDENTIFIERS Computer Literacy; Congress 96th; Microelectronics; *National Policy

ABSTRACT

This report is a current review and exposition of the role of information technology in education, with particular emphasis on the perspectives of leaders in the field and their views regarding its many potentials. The purpose of the study is to present an overview of the hearings and associated workshop on this topic held during the 96th Congress, within the broader context of a perceived need for the creation and implementation of a cohesive national policy governing the management of our information resources. Not only are the thematic and factual contents of these sessions analyzed and synthesized, but their commentary on the state of education in the United States and the impact of advanced technology is attuned to the special interests of those legislative oversight groups which must plan for the future. (Author/LLS)

[COMMITTEE PRINT]

INFORMATION TECHNOLOGY IN EDUCATION: PERSPECTIVES AND POTENTIALS

REPORT

PREPARED FOR THE

SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
NINETY-SIXTH CONGRESS
SECOND SESSION

BY THE

CONGRESSIONAL RESEARCH SERVICE
LIBRARY OF CONGRESS

Serial QQQ

DECEMBER 1980

Printed for the use of the Committee on Science and Technology

U.S. GOVERNMENT PRINTING OFFICE
77-352 O WASHINGTON : 1981

COMMITTEE ON SCIENCE AND TECHNOLOGY

DON FUQUA, Florida, *Chairman*

ROBERT A. ROE, New Jersey
MIKE McCORMACK, Washington
GEORGE E. BROWN, Jr., California
JAMES H. SCHEUER, New York
RICHARD L. OTTINGER, New York
TOM HARKIN, Iowa
JEROME A. AMBRO, New York
JIM LLOYD, California
MARILYN LLOYD BOUQUARD, Tennessee
JAMES J. BLANCHARD, Michigan
DOUG WALGREN, Pennsylvania
RONNIE G. FLIPPO, Alabama
DAN GLICKMAN, Kansas
ALBERT GORE, Jr., Tennessee
WES WATKINS, Oklahoma
ROBERT A. YOUNG, Missouri
RICHARD C. WHITE, Texas
HAROLD L. VOLKMER, Missouri
DONALD J. PEASE, Ohio
HOWARD WOLPE, Michigan
NICHOLAS MAVROULES, Massachusetts
BILL NELSON, Florida
BERYL ANTHONY, Jr., Arkansas
STANLEY N. LUNDINE, New York
ALLEN E. ERTEL, Pennsylvania
KENT HANCE, Texas

JOHN W. WYDLER, New York
LARRY WINN, Jr., Kansas
BARRY M. GOLDWATER, Jr., California
HAMILTON FISH, Jr., New York
MANUEL LUJAN, Jr., New Mexico
HAROLD C. HOLLENBECK, New Jersey
ROBERT K. DORNAN, California
ROBERT S. WALKER, Pennsylvania
EDWIN B. FORSYTHE, New Jersey
KEN KRAMER, Colorado
WILLIAM CARNEY, New York
ROBERT W. DAVIS, Michigan
TOBY ROTH, Wisconsin
DONALD LAWRENCE RITTER, Pennsylvania
BILL ROYER, California

HAROLD P. HANSON, *Executive Director*
PHILIP B. YEAGER, *General Counsel*
REGINA A. DAVIS, *Administrator*
PAUL A. VANDER MYDE, *Minority Staff Director*

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

GEORGE E. BROWN, Jr., *Chairman*

JAMES H. SCHEUER, New York
DONALD J. PEASE, Ohio
TOM HARKIN, Iowa
ALLEN E. ERTEL, Pennsylvania
KENT HANCE, Texas
WES WATKINS, Oklahoma

HAROLD C. HOLLENBECK, New Jersey
ROBERT W. DAVIS, Michigan
DONALD LAWRENCE RITTER, Pennsylvania

LETTER OF TRANSMITTAL

COMMITTEE ON SCIENCE AND TECHNOLOGY,
U.S. HOUSE OF REPRESENTATIVES,
Washington, D.C., December 22, 1980.

Hon. DON FUQUA,
Chairman, Committee on Science and Technology, U.S. House of Representatives, Washington, D.C.

DEAR DON: We are transmitting herewith a report, "Information Technology in Education: Perspectives and Potentials", prepared by the Congressional Research Service at the joint request of the Subcommittee on Science, Research and Technology of the Committee on Science and Technology and the Subcommittee on Select Education of the Committee on Education and Labor.

The Subcommittees requested an analysis by CRS of their joint hearings and workshop held in April, 1980 on Information Technology in Education and of related issues from the October 1979 hearings on Information and Communications Technologies Appropriate in Education. The transmitted report consists of two parts, the first being conclusions and recommendations written by the staff of the Subcommittee on Science, Research and Technology based on the hearings and the CRS analysis.

The witnesses at both sets of hearings stressed the importance for our nation's economic interests of developing skills in information technology through education and training. The Subcommittee believes that this report provides a useful analysis of the actual and potential contributions of information to the quality and productivity of the educational process itself, as well as to the improvement of general scientific and technological literacy in our society. We commend it to your attention and to the attention of the Members of the Committee on Science and Technology.

Sincerely,

GEORGE E. BROWN, Jr.,
Chairman, Subcommittee on Science, Research and Technology.

LETTER OF SUBMITTAL

CONGRESSIONAL RESEARCH SERVICE,
THE LIBRARY OF CONGRESS,
Washington, D.C., December 19, 1980.

Hon. GEORGE E. BROWN, Jr.,
Chairman, Subcommittee on Science, Research and Technology, Committee on Science and Technology, and

Hon. PAUL SIMON,
Chairman, Subcommittee on Select Education, Committee on Education and Labor, House of Representatives, Washington, D.C.

DEAR MESSRS. BROWN AND SIMON: I am pleased to submit this report entitled "Information Technology in Education: Perspectives and Potentials," prepared at the joint request of the Subcommittee on Science, Research and Technology of the Committee on Science and Technology and the Subcommittee on Select Education of the Committee on Education and Labor, both of the U.S. House of Representatives.

This study presents an overview of the roles and impacts of information technology—computers, telecommunications, teaching machines, audio and video devices—associated with its application in the educational environment.

Following an executive summary which sets forth the essential facts and associated observations related to this complex topic, an introductory section underscores the objective of the report, the multifaceted significance of the problem, and possible options for congressional initiative. The evolution of the various technologies now employed by educational administrators and instructors is examined in order to establish a suitable basis for determining better their future potential. Next, a chronology of selected events and reports reflecting key public and private sector endeavors is available, after which an exposition of legislative actions by six Congresses (during the period 1969–1980) is presented. The focal area of the report, as directed by the requesters, is a series of two hearings plus a technical workshop conducted during the 96th Congress. These are treated in detail, as the witness statements and their exchanges with congressional personnel are discussed within the context of stated objectives and prior legislative enactments. The recommendations of the six workshop groups, along with a useful identification of salient issues, also are featured. A series of appendices offers pertinent illustrative project descriptions, milestone writings, and selective material on legislative measures.

The direction of this project was the responsibility of Robert L. Chartrand, our Senior Specialist in Information Policy and Technology, who was the chief author and editor. Jerry Borrell, Research

Assistant to the Senior Specialist, prepared Chapters II and III, performed the extensive background research requisite for Chapter IV, and helped assemble the numerous appendices. Manuscript preparation was accomplished with the significant contribution of Hildegard Cote, executive secretary to the Senior Specialist. The manuscript was reviewed by Dr. K. Forbis Jordan, CRS Senior Specialist in Education. This contribution to the House Subcommittee on Science, Research and Technology and the House Subcommittee on Select Education was coordinated with and reviewed by Dr. Grace L. Ostenso and Dr. Robert Smythe of the former Subcommittee staff.

On behalf of the Congressional Research Service, I should like to express my appreciation for the opportunity to perform this challenging and timely assignment.

Sincerely,

GILBERT GUDE,
Director.

LETTER OF REQUEST

COMMITTEE ON SCIENCE AND TECHNOLOGY,
U.S. HOUSE OF REPRESENTATIVES,
Washington, D.C., July 9, 1980.

Hon. GILBERT GUDE,
Director, Congressional Research Service, Library of Congress, Washington, D.C.

DEAR GIL: As you know, our respective Subcommittees cosponsored a seminar on Information Technology in Education on April 2 and 3. As we indicated earlier, the Congressional Research Service staff made a valuable contribution to the planning and success of that seminar.

At this time, we would again like to request the services of the Congressional Research Service staff to prepare an analysis of the hearings. We would appreciate it if the analysis could be developed under the guidance of Mr. Robert Chartrand and include the April hearings as well as related issues from the October 1979 hearings on Information and Communications Technologies Appropriate in Education. If feasible, we would like the analysis to include: an executive summary, introduction, analysis by hearing or issue, and suggested options for Congressional initiatives which the Subcommittees could utilize as a basis for formulating recommendations.

We sincerely appreciate the assistance and expertise of your staff in helping us address the challenges of information technology in education.

Sincerely,

GEORGE E. BROWN, Jr.,
Chairman, Subcommittee on Science, Research and Technology.
PAUL SIMON,
Chairman, Subcommittee on Select Education.

CONTENTS

APPENDIXES

LIST OF FIGURES

CONCLUSIONS AND RECOMMENDATIONS OF THE SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

The advances of the last decade in microelectronics and telecommunications have greatly increased the quality and range of services provided by information technology, often at dramatically reduced cost. This "Information Revolution" has brought about great changes in business and commerce, in recreational opportunities, and even in the way we as individuals think about the world.

The effects of this revolution are perhaps least apparent in our educational institutions and practices. There are many reasons for this, some economic, some historical, and some having to do with the inertia and inherent conservatism of large systems. Yet it is unrealistic to imagine that the information revolution will not, in its course, have a profound impact on education. In fact, a close look at the whole educational enterprise—including industrial and military training, continuing and professional education, and special education, as well as teaching in traditional classrooms—reveals that information technology has already made significant penetration into these activities. The rate of the penetration has not been as rapid as many had hoped or predicted ten or twenty years ago. However, there is virtual unanimity of opinion that information technology will be an increasingly important part of education at all levels. The only disagreements center around the rate of this increase and the precise ways in which the technology should be employed.

POTENTIAL FUNCTIONS OF INFORMATION TECHNOLOGY IN EDUCATION

Information technology will have three important functions in the education milieu of the future. First, it has the potential to increase educational productivity. It offers the possibility of increasing the learner's productivity through individually-paced computer-aided exercises, with frequent progress monitoring and feedback. It will also add to the productivity of teachers and administrators by increasing the quality and availability of data on individual and collective achievement, and by permitting rapid and accurate exchange of these data via electronic networks. The capability of the technology to perform this first function is not in dispute, although good working examples are not yet numerous or highly visible.

The second function—the role of computers, videodiscs, and other technologies in enhancing the quality of education—is somewhat more speculative. The new technologies do more than simply allow us to do the same things better—they offer the possibility of doing things we never thought of before. Additional research and development must be pursued before most of this promise becomes reality, but some of the exciting new work with computer-managed videodiscs offers a glimpse of future possibilities. In the not-too-distant future, an intelligent computer armed with "knowledge bases" and sophisticated graphics capabilities may be able to query a learner (perhaps in natural language) to discover the extent of his knowledge, and carry on a dialogue at the appropriate level with the learner. Or the computer may be able to diagnose systematic conceptual errors made by the learner and work with the learner to correct them. Clearly more research in the development of cognitive skills and in the representation of knowledge will be needed before this second function approaches realization.

The third educational function of information technology will be to prepare citizens to deal with a future in which information products and services will comprise a very large portion of our national and international economy. The efficient generation and transmission of information is a critical ingredient of national productivity and a vital aspect of national security. A recent report transmitted to the President by the National Science Foundation and the Department of Education emphasizes the weakness of American education in science and technology preparation for non-specialists and points out a present and anticipated future shortage of highly-trained computer scientists.

Preparation in "computer literacy" will not and cannot take place entirely in the schools and colleges, although these institutions must play a major part. Perhaps the most striking post-1970 development in information technology is the microcomputer. These small but sophisticated machines will allow libraries, science museums, and perhaps a new breed of "public information centers" to contribute to the development of computer literacy, for adults as well as for students. The continually decreasing cost of the microcomputer will allow the home to become an enriched learning environment, with consequences that could be profound.

Federal Involvement in Information Technology in Education

In seeking the proper nature and level of Federal involvement in information technology in education, there are urgent immediate questions as well as some important long-range impacts which warrant consideration. The more immediate problems fall into three broad categories:

(1) Development and evaluation of the technology and of related educational materials;

(2) Training of educational personnel to recognize the potential contributions of information technology to learning, to enhance instruction through the use of this technology, and to contribute to the improvement of courseware;

(3) Dissemination of curricular materials and of reliable information about the nature and effectiveness of hardware and courseware.

All of these, of course, will require sustained long-term efforts, but they are pressing problems which need attention now. In approaching these problems, a fourth consideration needs to be borne in mind:

(4) Preserving and strengthening traditional local control and initiative in education while at the same time bringing the benefits of new educational technology into effect as rapidly as possible.

Development and Evaluation of Technology and Educational Materials.—The Federal government has been deeply involved in the development and evaluation of information technology for a long time, and the Subcommittees believe that this involvement should continue. The performance of the private sector in hardware and software development has been impressive indeed, but educational markets have not been the driving force behind most of this development. Education presents a largely disaggregated market, and identifiable subareas with a critical need for technology, such as special education, do not offer a large target for profits. The development of "generic" software appropriate for educational uses—such as input-output systems for nonreaders, hearing-impaired persons or for the physically handicapped —may need continuing Federal stimulation.

The most pressing and important problem of development is the creation of high-quality educational courseware. Many promising starts with computers in the classroom have fallen with a thud once the novelty of the computer wore off and the inadequacy of the course materials became apparent. Generating incentives for private sector courseware development is a major concern. A strong body of opinion holds that only through Federal intervention in the promotion of compatibility standards for computer-based courseware can a market be developed that is sufficiently large to draw the serious attention of "big" developers of educational materials. Protection of intellectual property through copyright or other restrictions is also a serious issue.

It appears that the private sector, including both equipment vendors and publishers, is on the verge of major initiatives in courseware development and promotion. The nature and quality of these initiatives will have considerable bearing on the future of information technology in education, and it is of the greatest importance that the educational establishment have early and continued involvement in these efforts. There is a need for an ongoing forum in which the Federal government, educational organizations and institutions, and the private sector can join forces to identify areas of need and maximum opportunity and shape efforts accordingly. One mechanism that has been suggested for this purpose is the creation of regional institutes or "centers of excellence" as a joint public-private venture, for advanced research and development, validation, and distribution of exemplary curricula.

The proliferation of microcomputers has brought with it a prodigious outpouring of course materials for micros, many of them developed directly by teachers. These materials are of widely varying quality. The concept that the development of good courseware is an extremely difficult undertaking, at least as difficult as writing a good textbook, has not been generally recognized. A concerted effort to identify and support talented individuals to author courseware, perhaps including a fellowship program for promising authors, might result in substantial production of high-quality material.

The torrent of course materials has made evident an urgent need for the evaluation of courseware. Such evaluation needs to take full cognizance of the needs and limitations of the classroom teachers and participating students who will use the materials. Reviewing processes for newly-developed courseware would be very helpful to school districts and individuals faced with a deluge of course materials, many of which are currently of dubious quality. In particular, courseware which is developed under Federal auspices should include provision for careful evaluation and validation.

Training of Educational Personnel.—The training of educational personnel in the use of information technology has been purported to be as much a problem of attitudes as of skills. Teachers, administrators, and Boards of Education must be convinced that the proposed use of technology is humane; that it can make enough of a positive contribution to the quantity and/or quality of instruction to justify its expense; and that it will not demean or subvert the role of the teacher in the classroom. These needs point up the importance of building a solid base of knowledge about the costs and capabilities of technology in education, through testing and evaluation. They also imply that decisions to introduce information technology into the classroom must be made with the meaningful participation of teachers and lay boards.

Opportunities to familiarize teachers and administrators with information technology need to be sought and to be created. Special purpose institutes are one means of doing this; they might focus on a specific discipline, on a certain configuration of technologies, or on evaluation of effectiveness. In-service training and continual updating of skills will also be needed in a field moving as quickly as information technology.

Attention needs also to be directed at the institutions of higher education which train teachers. Often these institutions are ill-equipped to provide training in instructional uses of information technology. They need better equipment and guidance in the development of appropriate curricular materials.

Public-private cooperation through such activities as loan of personnel and equipment sharing could help upgrade the capabilities of schools and colleges to use information technology. Revision of tax policies and royalty restrictions may be needed to stimulate such activities.

Dissemination of Curricular Materials.—The third area of urgency is the dissemination of curricular materials and of information about the capabilities of hardware and software. Here again the Federal government has long played a role, through its support of CONDUIT and the new dissemination program at the Northwest Regional Education Laboratory, and in other ways. The abundance of course materials for micros makes necessary the sifting, classifying, and evaluation of these materials.

One way of disseminating results is through large-scale demonstrations of promising new applications. This need not require the creation of new institutions, although it certainly will require the coordinated activity of existing institutions. Some appropriate projects for such demonstrations could probably be identified today. In seeking such projects, the educational establishment should begin to look beyond its traditional boundaries for models. Military and industrial training activities have developed some sophisticated uses of information technology, some of which offer great promise for schools and colleges.

Beyond demonstrations, another step could be the creation of a clearinghouse, or the expansion of existing facilities, to consolidate and disseminate information about information technology. Eventually, this activity could be carried out through an electronic network connecting libraries and other information centers. It seems unlikely that such a network will spring into being without assistance from the Federal government.

Maintaining Local Educational Initiatives While Facilitating the Application of Beneficial Technology.—Strong local community interest and participation has been a historic strength of the U.S. educational system. Whatever innovations are planned and adopted should be designed to strengthen and use this asset and must guard against weakening it. This implies that much effort must be devoted to insuring the participation not only of local school officials and planners, but also of parent and citizen educational groups. Such participation would be enhanced by a vigorous local-oriented educational and demonstration program, perhaps in partnership with the private sector through such mechanisms as local educational technology "fairs."

Long-Range Implications of Information Technology

The longer-range implications of information technology in education include the need for future research and development in cognitive science and software engineering as well as economic and social impacts to be anticipated from information technology. The first category centers primarily on efforts to develop information technology-based learning systems that allow students broad opportunities for initiative. These efforts will require an increasingly sophisticated interaction between cognitive sciences and educational technology in order to create fruitful machine-assisted learning environments. Such activities are complex and time-consuming and will need to be nurtured and supported.

The second category of long-range implications derives from the future near-ubiquity of microcomputers and other information systems in the home and workplace. The possibility of meeting educational needs in the workplace and in the home may, in the shorter term, generate pressure for wider use of information technology in schools and colleges. In the longer run it could have a great impact on the role and structure of educational institutions at all levels. This prospect in turn raises some troubling questions about the possible effects of decentralized learning systems on individual social development and interpersonal relationships.

Even more disturbing is the question of equity. Proponents of educational technology have praised its ability to equalize opportunity by delivering quality programs and services to remote areas or to disadvantaged sectors of the population. Even if we make the unlikely assumption that everyone can purchase the needed equipment, taking advantage of this technology depends not only on the availability of hardware but also on the presence, in the school, workplace, or home, of people trained to accept and use it for educational ends. Promoting equality in this dimension is a major challenge.

Finally, there is a question central to the values of a democratic society, that of preservation of privacy and individual liberties. This concern arises both from the growing vulnerability of computerized data to unauthorized access and the fear that technology-based education will emphasize facts over concepts and principles and could be used to propagandize and condition tastes and beliefs. This possibility makes it all the more important that development and application of technology-based systems be accompanied by frequent evaluation and review by informed citizen opinion.

Recommendations

The use of information technology in education and training should be viewed as an important contribution to the development of scientific and technological literacy. As such it has significant implications for our national economic productivity and for national security, and should be accorded a high priority in Federal support.

The diffuse legislative authority and the levels of current funding of programs concerning instructional uses of information technology should be reassessed in the light of the increasing significance of information and of electronic technology for our national well-being.

Based on the Congressional oversight activities analyzed in this report, the Subcommittees propose the following recommendations for: immediate actions, long-range concerns, and improving the instructional and training functions of the Federal Government through the use of information technology.

I. Recommendations for Immediate Actions

A. Development of an implementation plan for Federal coordination and support of instructional uses of information technology—

1. The Director of the Office of Science and Technology Policy should convene a Task Force for information technology in education composed of:

   a. A Coordinating Group including chairpersons of the existing interagency committees with responsibilities in this area, such as the Subcommittee on Educational Technology of the Federal Interagency Committee on Education, the Committee on Computers in the Learning Society, and the Interagency Group for Computer-Based Training, and representatives from each of the principal Federal agencies involved with instructional uses of information technology; and

   b. An Advisory Committee including representatives of equipment manufacturers and the publishing industry, educational and professional associations, university and other centers involved in courseware development, and state and local officials.

2. The function of the Task Force would be to develop an objective-based implementation plan with particular emphasis on: (a) development of the technology and appropriate courseware; (b) training of educational personnel; (c) validation and evaluation of course materials and dissemination of related information.

In the development of this plan the Advisory Committee would provide advice to the Coordinating Group. Special attention would be given to strengthening and maintaining local initiative and participation in the educational system while facilitating access to the benefits of new education technologies.

a. Development of the technology and appropriate courseware.—The Coordinating Group should make a determination of the appropriate nature and level of Federal support and program focus for technology and courseware development.

The Advisory Committee would place particular emphasis on recommending strategies for creating exemplary course materials to be used with computers, videodiscs, and other information technologies. Its functions would include:

(i) Studying and recommending options for compatibility standards to increase the transportability of courseware;

(ii) Examining potential disincentives to private sector investment in courseware development, including royalty restrictions, tax, patent, and copyright laws, communications regulations, and antitrust policy, and recommending changes needed to facilitate development of high-quality courseware;

(iii) Identifying an appropriate role and funding level for the activities of the regional education laboratories and centers in technology and courseware development;

(iv) Assessing the feasibility and desirability of establishing "centers of excellence" for large-scale efforts in advanced research and development of courseware; and

(v) Considering options for funding such centers, if recommended, including the feasibility of a small tax on equipment sales and telecommunications transmission.

b. Development of programs for training of educational personnel.—Action should be taken as quickly as possible to increase opportunities and incentives for teachers and administrators in schools and colleges to familiarize themselves with the instructional potential of information technology.

Such a program should be based on solid assessment of the institutional barriers, including teacher attitudes and lack of incentives, to the instructional use of information technology, and should include in particular:

(i) Consideration of increased use of special-purpose institutes for teachers and administrators;

(ii) Measures to facilitate in-service training and support services for innovative projects;

(iii) Measures to enhance the training capabilities of institutions involved in the preparation of prospective teachers; and

(iv) Measures to encourage cooperation of the private sector with schools and colleges in equipment sharing and personnel loans.

c. Validation and evaluation of course materials and dissemination of related information.—(i) Attention should be directed to promoting and encouraging the improvement of existing mechanisms for cataloging, evaluating, and disseminating information about courseware, particularly that designed for microcomputers.

77-352 O - 81 - 2

Methods should be sought to catalyze and, if necessary, subsidize the formation and expansion of review groups to provide information to individuals and educational institutions about the performance and implementation costs of educational software. An appropriate role for the National Diffusion Center in this activity should be identified.

(ii) Careful consideration should be given to demonstrating, on a large scale, the potential of information technology for education by means of carefully chosen, exemplary projects.

Particular attention might be given to projects combining the capabilities of computers and satellite broadcast or cable video systems in novel and fruitful ways.

(iii) Federal support of education should recognize the impact of institutions such as libraries and science museums in the educational process.

Such institutions can play an important role in the development of familiarity with information technology by non-traditional learners, as well as by children.

Programs of these institutions aimed at public understanding of technology should be encouraged and supported.

The creation of electronic library networks, with large urban libraries as network centers, should be encouraged and supported.

3. The implementation plan should include as a minimum:

a. specific objectives based on identified needs for Federal coordination and support of instructional uses of information technology;

b. coordination strategies, timeframes, and resource requirements for implementation;

c. appropriate areas of responsibility for the principal Federal agencies involved;

d. appropriate areas for cooperative interagency programs, including the evaluation of the ability of existing interagency groups to coordinate and review such programs;

e. feasible options as needed to aid or supplant existing mechanisms in achieving the stated objectives; and

f. examination of existing legislative authorities and consideration of potential modifications needed to achieve stated objectives.

B. A copy of the reports and recommendations of the six workshop discussion groups at the April, 1980 hearings should be forwarded immediately to the Secretary of Education.

The Department should be asked to assess the recommendations and to comment on the possibility of encompassing certain of these in the Department's immediate and long-term priorities.[1]

[1] This action was taken by the Subcommittees in April 1980. The Secretary responded in a letter of September 1980, to the Subcommittee chairmen, and announced the formation of a Department-wide Task Force on Learning and Electronic Technologies, to be chaired by the Assistant Secretary of Educational Research and Improvement. The Task Force was to undertake "a series of activities leading to the development of a Department strategy," including: "taking inventory of the programs and projects in education that have important technology components; assessing existing legislative authorities for supporting such activities and analyzing potential modifications in them; identifying areas of maximum opportunity for the application of technologies to learning over the next three to five years or more; assessing problems and constraints of particular importance to the Department; and reviewing whether we are using the tools at our command in an effective and coordinated way."

II. RECOMMENDATIONS REGARDING LONG-RANGE CONCERNS

Congress and the Executive Branch should recognize that the instructional use of information technology is progressing rapidly and requires a long look ahead in order to plan judiciously.

A. Fedral support of research and development in information science and technology should give important consideration to—

1. *Research in the cognitive sciences* aimed at understanding how information is organized and knowledge is represented; and

2. *Research into the "human factors" of man-machine interaction,* including input-output formats, health effects of information technology, and social and psychological effects of machine-assisted learning.

B. The Congressional authorization process for scientific research and development should be made sufficiently flexible to permit reasonable guarantees of continuing support for long-term projects.

The design, implementation, and evaluation of projects involving the use of information technology in education often takes several years, and, absent an expectation of stable funding levels, investigators may avoid long-term projects of potential significance in favor of "safer" short-term commitments.

C. Congress and the Executive Branch should begin to anticipate and to plan for the significant impacts on educational, political, and social institutions that may result from the widespread use of information technology in education and elsewhere.

In particular, the role of traditional educational institutions may be changed by the ability of information technology to make educational resources available to homes and workplaces, as well as to schools. The ability of the present institutional structure to carry out long-range planning for effects of this magnitude should be carefully evaluated, and alternative structures proposed where necessary.

III. RECOMMENDATIONS FOR IMPROVING THE INSTRUCTIONAL AND TRAINING FUNCTIONS OF THE FEDERAL GOVERNMENT THROUGH THE USE OF INFORMATION TECHNOLOGY

A. The Office of Personnel Management and other agencies engaged in large-scale education and training of Federal employees should make a special effort to demonstrate cost-effective uses of information technology in their own training operations.

In particular, evaluation should be made of potential cost savings realizable by replacing centralized activities by on-site training using appropriate telecommunications technology.

B. Congress should make appropriate use of information technology in conveying the results of its hearings, investigations, and other activities to the public.[2]

---

[2] In response to this recommendation the Committee on Science and Technology and the Committee on Education and Labor have requested that the three part videotape series of the April 1980 joint hearings, workshop and demonstration be made available to the public The three tapes may be purchased at a cost of $60 each for Tape 1 and 3 and $85 for Tape 2, from the Office of the Clerk, U.S. House of Representatives, H-105 Capitol, Washington, D.C. 20515.

SUMMARY

There is a tremendous amount of effort being directed, in all sectors and at all levels, at the uses of information technology in education. The need to coordinate and to help direct this effort is urgent. Although education in the United States is largely a state and local responsibility, the high costs associated with hardware and software development make it unlikely that substantial progress can be made without a continuing high level of involvement by the Federal government. The need to equalize opportunity, and the potential gains in productivity that a technologically skilled workforce could provide, argue for renewed commitment by the Federal government. The Subcommittees urge that such a commitment be made.

INFORMATION TECHNOLOGY IN EDUCATION: PERSPECTIVES AND POTENTIALS

PREPARED FOR THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

(By Robert L. Chartrand, Senior Specialist in Information Policy and Technology, and Jerry Borrell, Senior Research Assistant)

CONGRESSIONAL RESEARCH SERVICE
LIBRARY OF CONGRESS

It is the peculiar business of education to teach people how to use the liberty they inherit and how to pass it on to the next generation, enlarged, enriched, and made more secure.

WALTER LIPPMANN,
"The South and the New Society," in
Social Forces, VI (1927), p. 30.

Where human institutions are concerned, love without criticism brings stagnation and criticism without love brings destruction. The swifter the pace of change, the more lovingly men must care for and criticize their institutions to keep them intact through the turbulent passages.

JOHN GARDNER,
The Recovery of Confidence, p. 30.

Information technology means the collection, storage, processing, dissemination and use of information. It is not confined to hardware and software, but acknowledges the importance of man and the goals he sets for information technology, the values employed in making those choices, the assessment criteria used to decide whether he is controlling the technology and is being enriched by it.

Information Technology:
Some Critical Implications
for Decision Makers, 1972, p. v.

EXECUTIVE SUMMARY

Cognizant of the need for a current review and exposition of the role of information technology in education, with particular emphasis on the perspectives of leaders in the field and their views regarding its many potentials, the Subcommittee on Science, Research and Technology of the House Committee on Science and Technology, together with the Subcommittee on Select Education of the House Committee on Education and Labor, requested the preparation of this report by the Congressional Research Service.

The purpose of this study is to present an overview of the hearings and associated workshop on this topic held during the 96th Congress within the broader context of a perceived need for the creation and implementation of a cohesive national policy governing the management of our information resources. Not only are the thematic and factual contents of these sessions analyzed and synthesized, but their commentary on the state of education in the United States and the impact of advanced technology is attuned to the special interests of those legislative oversight groups which must plan for the future.

Although the 1979–1980 hearings are regarded by their sponsors as concentrating on the "likely impact of information technology on teaching and learning and on our educational institutions," it is recognized that any such "foresight" thrust must be made with a sufficient understanding of that which has gone before: the public laws with provisions affecting the development and application of appropriate tools and techniques, executive branch directives and programs pertinent to this focal area, and a wide range of private sector initiatives. In preparation for this oversight activity, an approach was postulated which stressed that "if public policies are to be responsive to the needs of our 'Information Society,' we must develop mechanisms and institutions with the flexibility to adapt to technological change and to cope, in a humane and equitable way, with the increasingly interdisciplinary nature of new knowledge."

As the intention of focusing anew on this area became a matter of broadening awareness, a singularly broad community of interested and already active organizations expressed a desire to participate. Included in this grouping were academic administrators; laboratory and computing center directors, and researchers; information industry system designers, courseware creators, and project managers; government policymakers and program overseers; foundation, corporation, and association executives; and individual information scientists, librarians, and lawyers. Their statements, and often engrossing exchanges with congressional Members and staff, enhanced legislative understanding of salient educational needs for innovation, recent technological developments, and areas for possible legislative action.

Serving as a backdrop for the explicit witness treatments of information technology—computers, telecommunications, microforms, satellites, audio and video configurations—was a national picture of several interwoven issues:

Equal access to education for all students

A need for national performance guidelines and standards

Competition for funding among numerous social service programs

Funding responsibilities, in education, of local, State, and Federal institutions

Appropriate focus of Federal programs in various educational areas

Diminishing resources and the need for a reprioritization strategy

The attention of those organizing the hearings and workshop was not limited to a limited number of educational areas. To the contrary, all major facets were addressed: elementary education, secondary education, higher (post-secondary) education, adult education (including military and corporate programs), and education for the handicapped, gifted, and those whose location caused special problems. The concept of educational outreach surfaced often, and various approaches to moving outside the traditional schoolhouse walls were examined, including the home, the office, the library as a community information center, and mobile facilities. With the advent of satellite communications the alternatives continue to broaden, and now can encompass linkages with overseas locations.

In accordance with the stated objectives of the hearings—"to enhance the awareness of the Congress, the executive branch, and the private and public sectors of the potential educational benefits of new information and telecommunications technologies, and second, the possible social and economic impacts resulting from the widespread use of these technologies in the educational process"—the primary multi-faceted focus was on user needs, existing services, possible problem-solving approaches, and further applications of advanced technology. Within that framework, several high priority topics emerged:

The integration of computer-assisted procedures into established curricula

The development of special training (or retraining) courses for instructional personnel

The creation of meaningful orientation and education courses for administrative personnel and key lay organizations

The preparation and official endorsement of guidelines and standards governing CAI/CMI performance evaluation

The conceptualization, and subsequent official approval of long-range innovative programs which would allow validated measurement of computer-supported instructional courseware.

Over a span of more than 25 years, from the administration of President Eisenhower through that of President Carter, there have been a great number of endorsements, legislative measures, executive dicta, and actual programs. More than 30 public laws, either directly or incidentally, deal with some aspect of providing technological support to various educational activities. The blending of the innovative with the traditional is a *fait accompli*, and a sense of the former's potential has been instilled at many levels. The essence of this evolution is captured in a statement by H. A. Overstreet, who predicted that:[1]

> * * * the education of the future will be inventive-minded. It will believe so profoundly in the high value of the inventive or creative spirit that it will set itself to develop that spirit by all means within its power.

Ensconced within the introductory chapter of this report are found the conceptual basis for this series of hearings, as enunciated by their organizers, and a sense of the continuing legislative mandate for seeing that the state and projected future of education in the United States are well in hand. An appreciation of the significance, and complexities, of the problem is presented from the vantage points of those who have been involved in creating, translating, using, and evaluating the technology-supported products and services designed to facilitate the administrative and instructional endeavors in our educational system. In addition, several possible methodological approaches are delineated by which Congress could take the initiative in this area.

In Chapter II, a description of information technology which might be applicable to educational applications is presented, with five major areas meriting detailed discussion: computers, ergonomics, communications, information display, and information storage. The philosophy of their employment, and selected aspects of performance, are set forth in secular terms. Next, a review of selected milestone conferences, legislative actions including the passage of public laws, technology-based pilot projects and operational programs, and significant reports is featured in Chapter III.

Inasmuch as the 1979–1980 initiative by the two Subcommittees was the most recent in a long sequence of congressional actions, some of which have concentrated on issues and programs now undergoing reexamination, it was determined that a careful review of congressional hearings and reports treating this area, during the past six Congresses, would be beneficial. After a thorough preliminary study of candidate documentation reflecting such actions, a selection was made covering certain key efforts by 12 House subcommittees and three subcommittees in the Senate. In Chapter IV are found the highlights of the subject hearings—which sometimes included the results of focal studies on educational technology—along with commentary relating these developments to the evolving technology, newly derived applications, and perceptions of changing conditions in the educational environment.

The next three chapters contain the nucleus of the testimony, participant interaction, and supplementary documentation which comprised the 96th Congress hearings and workshop on information technology in education. Chapter V describes the October 1979 hearing, under the aegis of the House Subcommittee on Science, Research and

[1] Bradley, John P. and others. The International Dictionary of Thoughts. Chicago, Ferguson Publishing Co., 1969, p. 245.

Technology, where the emphasis was on obtaining a "broad overview on the state-of-the-art, including activities of other nations, as well as . . . related issues such as cost and benefits of alternative methods of education and training, mechanisms for increasing private sector commitment, and a forecast of technological changes." Specific comment was sought on H.R. 4326, a bill to create a National Commission to Study the Scientific and Technological Implications of Information Technology in Education. In April 1980, the jointly sponsored hearing and workshop were held, and Chapter VI presents an insight into the testimony and accompanying dialogue of this broad, fact-gathering hearing, with careful consideration of the experiences related by the witnesses and their recommendations for corrective legislative action. The technical workshop, with more than 125 participants, was designed to explore in greater depth six vital areas, with a discussion group assigned to each:

Group 1—Elementary and Secondary Education
Group 2—Post-Secondary Education
Group 3—Adult Education
Group 4—Special Education
Group 5—Development of Information Technology
Group 6—Public Planning for Education in the Information Society

The findings of these groups, which took the form of issue identification and specific recommendations, are found in Chapter VII, and were made part of the formal hearings documentation.

The selection of material for the appendices was dictated by a desire to complement narrative treatment of various technological undertakings with precise, illustrative examples of demonstration and operative projects. Also included are representative short papers providing an overview of the topic or prognostications concerning the potential of this technology for education, listings of participants at key functions, abstracted information on pertinent public laws, and a selective set of readings.

This composite study of a crucial, ever changing area is designed, in accordance with Subcommittee direction, to fulfill the need for a coherent, timely, and succinct general survey of the applications of information technology in education: past, present, and projected. Through this effort, and continuing supportive endeavors, the Congress will be better positioned to meet the challenge of developing and applying the expertise requisite to maximizing the positive impacts of these technologies in all educational environments.

I. INTRODUCTION

During the past quarter century, the Nation has been engaged both consciously and subliminally in a far-reaching "redefinition" of its values, priorities, and goals. Nowhere is this more evident than in the realm of education. From the days of the Founding Fathers, the record is one of unflagging great expectations on the part of the leadership and citizenry alike that universal education was an achievable objective. Its attainment would enable all Americans to communicate more effectively, savor life, participate in the political process, better comprehend the arts and sciences, and prepare for a chosen career.

Over the years, recurring efforts were made to increase the *quality* of education in the United States. Emphasis was placed on the training of teachers, the preparation of textbooks, and the construction of facilities, and all the while the integration of these elements drew the attention of conceptualists and implementers in all quarters of society. Education, in this country, became in the 20th century a multifaceted entity, with burgeoning activities serving those at the elementary, secondary, and university levels, as well as the throngs engaged in adult education (including the military and corporations). Especial attention came to be given to the handicapped, the gifted, and those whose remoteness of habitation might impose inhibitions on learning. Inherent in these endeavors seemed to be a readiness to strive for what an education could provide, perhaps best embodied in the words of Thomas Carlyle:[2]

> Knowledge conquered by labor becomes a possession,—a property entirely our own. A greater vividness and permanency of impression is secured, and facts thus acquired become registered in the mind in a way that mere imparted information can never produce.

A concurrent, emerging force with an undeniable potential for education also appeared on the scene during this period. Called "information technology," it was comprised of the spectrum of systems, devices, and man-machine techniques associated with computers, microform units, telecommunications, and audio and video equipment. It should be noted that technology in the classroom was scarcely unprecedented. For many years, teachers and students had utilized books, blackboards, charts, maps, filmstrips, motion pictures, phonographs, tape recorders, and language facilitators, and such "instructional tools" had been well accepted. But the newer technologies posed more of a threat to the established *modus operandi*, and required faculty training or retraining, the presence of often intrusive installations, and in many instances perceived changes in the teacher-student rela-

[2] Bradley, John P. and others. The International Dictionary of Thoughts. Chicago, Ferguson Publishing, 1969, p. 420.

tionship. It soon became evident that a convergence had taken place between a traditional essential societal service and an ineluctable, innovative force.

The implications were many, and during the 1950's and 1960's numerous false starts were made as promised performances involving the new systems were not fulfilled, cost-performance ratios proved unacceptable to teachers and budgeteers, and problems of integration damaged established routines and instructor confidence. The struggle continued on several levels, as funding ramifications impinged on Federal departments and agencies with oversight responsibilities, State and local officialdom, and the ultimate source of funding, the taxpayers. The marketplace in reality was less than predicted by corporate entrepreneurs who must finance new lines of equipment, software, or imaginative "courseware." Oftentimes, a projected experiment necessitated combining existing systems with configurations yet unproven in a given educational setting. The risk could be great. It would take time to upgrade the fledgling technology, overcome psychological resistance, and come up with approaches for incorporating the new methodology into existing instructional environments.

Many of the sought improvements did occur, as new and improved methods of information delivery which could facilitate educational instruction were developed.[3]

> Communications satellites have been used to transmit curricula and special programs to large urban areas and to such remote sites as Alaska, the Pacific Islands, and the Appalachians. Such systems also have been used for satellite conferences and meetings between educational groups, government representatives, and student bodies. Telecommunications networks have facilitated the sharing of resources, course work, and scientific and educational research at all levels of education. In a similar vein, "electronic blackboards" have linked instructors and off-site students without the need for costly travel. The development of videotapes and videodiscs may result in one-time investments for equipment capable of serving as high-volume, interactive information storage and retrieval sources of educational materials. Television, via broadcast or cable, continues to be a familiar medium for providing inexpensive mass dissemination of educational programs and learning experiences. The capabilities of interactive television systems for educational purposes also have been tested and put into operation in certain locales.

There were those who commenced referring to education as "an information processing system,"[4] and many more who saw this arena of activity as simply one more manifestation of the arrival of "The Age of Information."

---

[3] Information Technology in Education A Joint Hearing and Workshop, a pamphlet produced by Robert L. Chartrand and Jean Paul Emard for the Joint Hearings held by the Subcommittee on Science, Research and Technology and the Subcommittee on Select Education The pamphlet is printed in:

U S Congress. House. Committee on Science and Technology, Subcommittee on Science, Research and Technology, and the Committee on Education and Labor, Subcommittee on Select Education. Information Technology in Education. Hearings, 96th Congress, 2d session. Apr 2 3. 1980. Washington, U.S. Govt. Print. Off., 1980. 250 p. (Hereafter cited as Information Technology in Education: A Joint Hearing and Workshop).

[4] Goodlad, John I. and others Computers and Information Systems in Education. New York, Harcourt, Brace & World, 1966. p. 20.

Recognition of the potential for educational application of information technology has led to varied, and ever increasing, initiatives both within officialdom and elsewhere. The Congress, through its regular budgetary and program oversight hearings plus special issue-oriented sessions, has reflected public concern and served as a sounding board for a wide range of interest groups. Action within the Federal executive branch has taken the form of departmental directives, agency surveys, in-house and contractor studies, and recommendations which could lead to legislative authorization of yet further enterprises. In the private sector, a series of writings resulted from intensive scrutinies by commissions, foundations, corporations, associations, and universities. The breadth and depth of this community concerned with the roles and impacts of information technology in education are reflected tellingly in any analysis of the witnesses, panelists, and workshop participants appearing before congressional overseers.

With the advent of the 1980's, those charged with ensuring responsive legislative cognizance determined that a fresh look was in order. This was due in part to a continuing declaration that such initiatives were needed, but also because equipment cost considerations had changed radically for the better during the past decade. Such new action would not be taken in a vacuum, of course, and heavy reliance was placed on reviewing some of the milestone congressional and private sector reports issued during the past 15 years:

1966—*Automation and Technology in Education*, issued by the Joint Economic Committee.[5]

1970—*To Improve Learning*, the final report of the Commission on Instructional Technology.[6]

1972—*The Fourth Revolution: Instructional Technology in Higher Education*, a study released by The Carnegie Commission on Higher Education.[7]

1975—*Computers and the Learning Process in Higher Education*, prepared for The Carnegie Commission on Higher Education.[8]

1978—*Computers and the Learning Society*, a report by the House Committee on Science and Technology.[9]

Upon this foundation of fact and opinion, responsible oversight groups in the 96th Congress would create a further mechanism for gathering current and comprehensive commentary from those whose perspectives would best reflect the present status and potential of information technology in education.

OBJECTIVE OF THE REPORT

The final stage of the three-fold action taken during the 96th Congress by the Committee on Science and Technology and Committee on Education and Labor is the preparation of this report by the Congressional Research Service of the Library of Congress, at the joint

---

[5] U.S. Congress. Joint Economic Committee. Subcommittee on Economic Progress. Automation and Technology in Education. Committee Print. 89th Congress, 2nd session. Washington, U.S. Govt. Print. Off., 1966. 11 p.

[6] U.S. Congress. Committee on Education and Labor. Commission on Instructional Technology. To Improve Learning. Committee Print, 91st Congress, 2nd session. Washington, U.S. Govt. Print. Off., 1970. 124 p. (Hereafter cited as To Improve Learning)

[7] The Fourth Revolution: Instructional Technology in Higher Education. The Carnegie Commission on Higher Education. New York, McGraw-Hill, 1972. 110 p. (Hereafter cited as The Fourth Revolution.)

[8] Computers and the Learning Process in Higher Education. a report prepared for The Carnegie Commission on Higher Education. By John Fralick Rockart. New York, McGraw-Hill, 1975. 356 p.

[9] U.S. Congress. House. Committee on Science and Technology. Subcommittee on Domestic and International Scientific Planning, Analysis and Cooperation. Computers and the Learning Society. Washington, U.S. Govt. Print. Off., 1978. 48 p. (Hereafter cited as Computers and the Learning Society. Committee Print.)

request of the chairmen of the House Subcommittee on Science, Research and Technology and the House Subcommittee on Select Education. Utilizing the contents of the full hearings documentation (two volumes),[10] which includes the special booklet entitled "Information Technology in Education: A Joint Hearing and Workshop,"[11] this report will present an overview containing the highlights of the hearings within a context of past pertinent congressional activity.

Throughout its preparation, the guidance provided by Representative George E. Brown, Jr., Chairman of the Subcommittee on Science, Research and Technology, as he opened the hearings was heeded as a useful framework:[12]

> The objectives of the seminar are to enhance the awareness of the Congress, the executive branch, and the private and public sectors of the potential educational benefits of new information and telecommunications technologies, and, second, the possible social and economic impacts resulting from the widespread use of these technologies in the educational process. The potential for information and telecommunications technologies is clearly evident. The best means of utilizing and planning for the use of these technologies to achieve educational objectives is less obvious. Science and technology, like most other human activities, are capable of generating both good and bad consequences. I should underline that. The challenge before us is to apply or to develop expertise which will maximize the positive impacts of these technologies in all educational environments. That means the school, the workplace, and the home. Such expertise is not limited to scientific and technical knowledge, but it includes planning and evaluation processes to establish policies and implementation programs for achieving goals and shaping the tools and techniques necessary to achieve broad national goals.

In articulating the rationale for sponsoring this form of congressional exploration, Representative Carl D. Perkins, Chairman of the Committee on Education and Labor, asserted that:[13]

> * * * it is time that we reassess the revolution that is occurring in information technology and the likely impact of this revolution on our educational system. We believe that it is most appropriate to do this at a time when the creation of the Department of Education marks a new emphasis on education in this country.

---

[10] U.S. Congress. House. Committee on Science and Technology. Subcommittee on Science Research and Technology. Information and Communications Technologies Appropriate in Education (including H.R. 4326). Hearing, 96th Congress, 1st session Oct. 9, 1979 Washington, U.S. Govt Print Off., 1979. 250 p. (Hereafter cited as Information and Communications Technologies) and Information Technology in Education A Joint Hearing and Workshop.

[11] Information Technology in Education: A Joint Hearing and Workshop.

[12] Remarks of Representative George E. Brown in. Information Technology in Education A Joint Hearing and Workshop, p. 1, 2

[13] Remarks of Representative Carl Perkins in Information Technology in Education A Joint Hearing and Workshop, p. 3.

The significance of the workshop on information technology in education was underscored by Representative Paul Simon, Chairman of the Subcommittee on Select Education: [14]

> One could refer to this workshop as a "foresight" hearing, in contrast to the usual congressional practice of reviewing past programs and current problems * * * The new technologies, properly utilized, will give our society new capacities to understand itself and to understand other cultures. Inevitably, we will become more sensitive to the interdependent nature of this "spaceship earth" we inhabit. Inevitably, information will become less centralized, making education less institutionalized and more democratic. Inevitably, considerable change will occur in the organization and governance of our educational institutions.

These hearings, then, were illustrative of the jurisdictional oversight which must take place when cross-cutting issues arise. The first hearing, in October of 1979, was sponsored solely by the House Subcommittee on Science, Research and Technology. While seeking commentary from a variety of sources on the broader topic of "Information and Communications Technologies Appropriate in Education," a major discussion point was H.R. 4326, a bill to establish a national commission to study the scientific and technological implications of information technology in education.[15] As a result of that hearing, and the ensuing show of interest throughout the educational and technological communities, it was determined that a broader, up-to-date look at the present status and perceived potential of educational technology was warranted. This was undertaken through a joint initiative which led to the April 1980 hearing and associated workshop and a series of system demonstrations.

In order to derive the maximum benefit from the hearings, a carefully drawn group of speakers and panelists was assembled, representing key organizations and activities dedicated to exploring—or in some cases already involved in implementing—the use of information technology in education. A profile of these representative elements includes:

University and college administrators
University researchers and laboratory directors
Academic directors of computing centers
Corporate managers and senior scientists
Independent consultants in information science
Public sector project managers
Government policymakers and program overseers
Foundation and corporation executives, and
Librarians and lawyers

The areas of interest and concern reflected in the statements of 27 major witnesses and panelists, embellished in many instances by in-depth dialogues involving Subcommittee Members and staff, constitute an array of topics, legislative issues, and "targets of opportunity."

---

[14] Remarks of Representative Paul Simon in: Information Technology in Education, p 204.
[15] H.R. 4326, 96th Cong., 1st Sess., 125 Cong. Rec. 4092 (1979)

77-3// ^ - 81 - 3

In essence, they fulfilled the desire of the sponsoring Subcommittees to acquire useful information on user needs, existing services, possible problem-solving approaches, and further applications of advanced technology. But more specifically, arising out of these discussions were several sharply defined focal points, among which were:

The training or retraining of instructor personnel

The orientation and education of school administrators and boards of education

The criticality of developing high quality courseware

The integration of computer-assisted procedures into established curricula

The development of meaningful evaluation criteria for CAI/CMI systems and their components

The identification of realistic private sector initiatives

The provision of equal access to educational resources for all users, and

The trade-offs in funding alternatives, involving public and private sector sources

Augmenting these often intensive exchanges were the findings of the technical workshop, which had been designed to meet this charge from Representative Brown, who presided over both hearings:[16]

> We must rely on the experts such as those of you participating in this seminar, to derive a consensus which will direct us toward the appropriate goals and policies. The seminar participants represent a wide variety of interests and organizations. It is important that individual perspectives are exchanged in this seminar and beyond to devise priorities necessary to achieve educational objectives rather than to develop priorities based on the attributes of a single technology or single interest. We look forward to the expertise and perspectives of the seminar participants and our witnesses this morning.

The infrastructure of the workshop (or "seminar") allowed the volunteer groups, each led by an acknowledged authority in that field, to quickly address its chosen area, and develop a report featuring identifiable issues and specific recommendations, which are enumerated in Chapter VII. The six areas of purview: elementary and secondary education, post-secondary education, adult education, special education, development of information technology, and public planning for education in the Information Society.

Another useful dimension of this report, in accordance with the directions of the Subcommittees, is an exposition of the characteristics and uses of information technology, particularly as this would be helpful for those considering its application to various aspects of education. Supplementing the treatment of congressional initiatives regarding educational technology, for the period 1969–1980, is a chronology of selected events and reports designed to provide a more fulsome appreciation of pertinent past happenings.

[16] Remarks of Representative George E. Brown in. Information Technology in Education. p. 2.

It is the intent of this report, then, to synthesize and analyze not only the highlights of the featured hearings and workshop, but to furnish the cognizant committees of the U.S. House of Representatives with information that can be contributory to the future "development and implementation of a coherent national policy for the management of our information resources" [17] in this area. This is offered in the spirit exemplified by the words of Benjamin Disraeli who remarked that "The more extensive a man's knowledge of what has been done, the greater will be his power of knowing what to do." [18]

SIGNIFICANCE OF THE PROBLEM

Philosophers and pragmatists, presidents and prognosticators have offered, down through the years, a litany of observations about the importance of education to mankind. In the first instance, Jean Jacque Rousseau reminded his contemporaries that: [19]

> Education comes to us from nature, men, or things. The inward development of our faculties and organs is the education of nature; the use which we are taught to make of this development is the education of men; and what we gain from our own experience of the objects around us is the education of things.

In a different vein is this message from the jurist cum politician William Orville Douglas: [20]

> If we are to receive full service from government, the universities must give us trained men. That means a constant reorientation of university instruction and research not for the mere purpose of increasing technical proficiency but for the purpose of keeping abreast with social and economic change. Government is no better than its men.

Both in the White House and on Capitol Hill, a growing, deep-rooted concern about the effectiveness of the existing educational system has been articulated. The importance of making policy decisions at the level where education takes place elicited this comment from President Dwight D. Eisenhower: [21]

> We know that education, centrally controlled, finally would lead to a kind of control in other fields which we don't want and will never have. So we are dedicated to the proposition that the responsibility for educating our young is primarily local.

This theme, of ensuring a "voice" for education—administrators and instructors—at the city and county level in determining how technology is to be incorporated into school systems, surfaces periodically in the testimony contained in this report.

---

[17] Ibid. p. 2.
[18] Bradley, John P. The International Dictionary of Thoughts. Chicago, Ferguson Press. 1969. p. 420.
[19] Ibid. p. 245.
[20] Bradley, John P. The International Dictionary of Thoughts. p. 242.
[21] Ibid. p. 242.

President John F. Kennedy cautioned that "Our progress as a nation can be no swifter than our progress in education," [22] and this was amplified by Lyndon B. Johnson who addressed the increasingly crucial problem of the educationally disadvantaged: [23]

> We have entered an age in which education is not just a luxury permitting some men an advantage over others. It has become a necessity without which a person is defenceless in this complex, industrialized society . . . We have truly entered the century of the educated man.

Educational reform, with ramifications often beyond the prescience of the wisest observer, was seen by President Richard M. Nixon as a necessity, as indicated in his 1970 message proposing the creation of a National Institute of Education: [24]

> We need a coherent approach to research and experimentation. Local schools need an objective national body to evaluate new departures in teaching that are being conducted here and abroad and a means of disseminating information about projects that show promise.

He then sharpened the focus of his remarks:

> There comes a time in any learning process that calls for reassessment and reinforcement. It calls for new directions in our methods of teaching, new understanding of our ways of learning, for a fresh emphasis on our basic research, so as to bring behavioral science and advanced technology to bear on problems that only appear to be insuperable.

During the administration of President Jimmy Carter, the long-planned White House Conference on Library and Information Services was held (in 1979), at about the time that the new Department of Education was being established. In addition to creating the position of an Assistant Secretary for Educational Research and Development, an Office of Libraries and Learning Technologies was created. This directly reflected President Carter's promise of "providing leadership in developing new technologies and services." [25] He further stated that a redefinition of the Federal role in this area was in order, and would be contained in a revised Library Services and Construction Act: [26]

> This legislation will include such issues as: barriers to information access for the handicapped and disadvantaged; library networking and resource sharing; the role of large urban libraries and research libraries as centers for library resource networks; and new information technologies.

On another occasion, in appearing before the delegates of the White House Conference on Library and Information Services, he spoke of

---

[22] Bradley, John P. The International Dictionary of Thoughts p. 244.
[23] Ibid. p. 243
[24] U S President. 1970. Nixon Education Reform. March 3, 1970 Weekly Compilation of Presidential Documents. v. 6. Mar. 9, 1970 p. 304–314.
[25] U S. President. 1980. Carter Transmittal of the Report of the White House Conference on Library and Information Services Washington. U.S Govt Print Off, 1980 2 p. 96th Congress, 2nd session. 125 Congressional Record E5372.
[26] Ibid. p. E5373.

our changing times and the expanded role of the library as an adjunct to other "educational" institutions:[27]

Times change very fast. Information available to the world is exploding more rapidly than it can be accommodated, and the function of libraries is to collect information, to collate information, to assess information, to store information, and to let information be available to those who need it.

There are many people in our modern society who are isolated in some form or another. The deaf, the blind, the immobile, the afflicted, those who live in isolated communities are obvious examples. But there are others. Those who have a particular life career in a fairly narrow defined area, but who desire constantly to stretch their minds and to stretch their hearts, and to know more about the world around them, other people, opportunities for a more gratifying existence, are in the same category as those who are physically isolated.

* * * * * * *

I am not at all criticizing or playing down the importance of formal education, but no matter how broad an educational experience has been in a person's life, sometimes determined by the state of a person's birth or the wealth of a family or opportunities that all can't share—no matter how broad a formal education might be libraries are still important if that person desires to continue in education throughout one's life.

It should be noted that among the 64 resolutions passed at this White House Conference were those urging libraries "to take an increased role in literacy training; in improved access to information for all, including ethnic minority groups, the blind, the physically handicapped, and others who are not adequately served . . . the idea of the library as both a total community information center and as an independent learning center . . . the concept of the library as essential to a civilized society."[28]

Congressional concern, the main thrust of this report, has been expressed on dozens of occasions by the Members of the House of Representatives and the Senate, during consideration of proposed legislation in subcommittee and committee sessions, in public hearings, and in remarks during chamber debate. An embodiment of that concern is found in the opening statement of Representative Brown at the October 1979 hearing:[29]

There is an apparent need to develop and implement policy to guide the application of information and communications technologies to all levels of education. Full advantage of

---

[27] Presentation by President Jimmy Carter at the White House Conference on Library and Information Services, Washington Hilton Hotel, Nov. 16, 1979. Found in:
U.S. Congress. Senate. Committee on Labor and Human Resources. Subcommittee on Education, Arts, and Humanities International Information Exchange. Relevant Activities of the White House Conference on Library and Information Services. Committee Print, 96th Congress, 2nd session. Washington, U.S. Govt. Print. Off., 1980. p. 1906 108.

[28] The Final Report of the White House Conference on Library and Information Services—1979. Washington, U.S. Govt. Print. Off., 1980, p. 10.

[29] Remarks of Representative George E. Brown, Information and Communications Technologies, p. 1.

the socially desirable educational opportunities offered by a broad range of technologies must be pursued to increase intellectual productivity and enhance the quality of life.

Numerous other declarations of belief and support are featured in Chapters IV, V, and VI, as congressional panelists offered their perceptions of various problems and possible solutions, and interacted with those giving testimony.

As delineated earlier, the societal groups—often referred to as "stakeholders"—concerned with the development, use, and accountability of educational technology reflects myriad viewpoints and vested interests. These individuals and organizations are depicted graphically in Figure 1:[30]

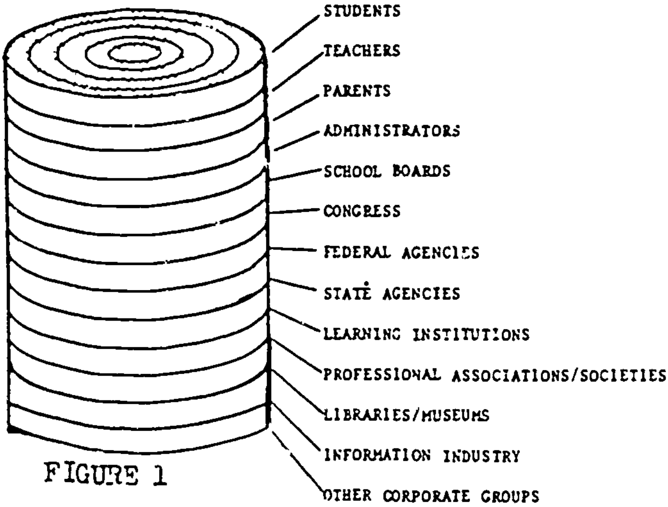


FIGURE 1

Fig 1—Stakeholders concerned with educational technology

Illustrative of the complexities of this kaleidoscopic problem area are the diverse approaches and emphases enunciated by witnesses representing segments of this stakeholder spectrum:[31]

A. Stanley Corey (school administrator)— . . . if we look at the larger context at America's social problem, our concern is not one of failure in a technical sense . . . [or] in the informational sense . . . the failure lies in the ability to produce self-actualizing, thinking young people.

Dr. Lewis M. Branscomb (corporate executive)—If we don't restrict our idea of education to the formal classroom experience in a conventional school environment, then it is clear that the impact of computers and communications is even greater.

Dr. F. James Rutherford (government administrator)—Federal agencies [should] . . . address the question of the public understanding of these technologies . . . the American school

[30] Information Technology in Education: A Joint Hearing and Workshop. p. 211.
[31] These illustrative quotations were taken from various source materials.

system ought to help them understand the strengths and uses and weaknesses of these devices.

Dr. Robert Hornik (professor)—We should not be concerned with the role of information technology in all of non-formal education, but the potential role for such a technology in meeting a particular need.

Marshall McLuhan (communicator)—Young and old alike now live in unique service environments of information. It is a many-layered environment. The inner layers are the familiar electric networks of telegraph and telephone and radio and TV. The outer layers are jets and satellites.

The commentary is thoughtful, ranges from the purely conceptual to the completely pragmatic, and leaves virtually no germane area untouched. Intrinsic to this often convoluted exploration are several reoccurring themes which may well serve as the harbinger of future delvings:

- Many of the basic assumptions underlying U.S. educational policies and practices will have to be revised and re-prioritized;
- Further exhaustive studies of integrating technology into the learning environments are a *sine qua non;*
- Bold new approaches to serving special educational constituencies are required, and must incorporate the technological potential;
- Information marketplace concepts and guidelines must be rethought and formalized in order to optimize the benefits of technology for systems providers and users alike; and
- Domestic and international information handling standards need to be formulated, negotiated, and implemented in order to effectuate far-reaching educational offerings.

A strong cautionary note is sounded by many observers, whose experience has shown that while information technology is indeed in existence, and available, there are other more important considerations which must be acknowledged and coped with. Professor Richard E. Spencer, Professor of Educational Psychology at the University of Illinois, proffered this opinion:[32]

> There is considerable "religiosity" associated with instructional technology—those that are in the field seem to believe that the potential is just lying there waiting to be tapped. This reveals an underlying assumption: that the system is adaptable to instructional technology, and that operations in this area will be welcome. Such an assumption has not been wholeheartedly validated.

Another perception of technology's place in the educational scheme was elicited from Mortimer Smith, Executive Director, Council for Basic Education:[33]

> There is a tendency among those working in the field of educational technology to assume that this is the only way to improve instruction and schools. I prefer an overall system that allows for alternate proven approaches, even if some of

[32] To Improve Learning, p. 87.
[33] Ibid., p. 73.

them are traditional. Look at some first-rate schools—Bronx High School of Science (New York City) and New Trier High School (Winnetka, Illinois) might serve as examples—and I suspect you will find that the human element, the human teacher, is still dominant.

A separate, residual quandary is the insufficient realization of the need for reform, even though the evidence supporting change is incontrovertible. Robert H. Finch, former Secretary of HEW states: [34]

> The establishment in lower and secondary education is probably the most encrusted in the entire world. They still are teaching children as we were taught thirty years ago. A child today who comes into kindergarten has had from 3,000 to 4,000 hours sitting in front of that television tube, absorbing unstructured data that takes him way past Dick and Jane. And the system just doesn't respond to that.

From the world of technology and its systems comes the reminder—in *The Automated State*—of the sometimes unanticipated effects: [35]

> Their presence puts hitherto unattainable goals within casual reach—and even sometimes make them no longer worth the candle. It goes on, in many cases, to replace these goals with new ones, many of which were not foreseen when the systems themselves were installed.

It has become apparent that there is no facile solution to this imbroglio, and perhaps the most useful approach—as might be inferred from the accompanying testimony—is to recall the challenging array of educational issues facing the Nation during the 1980's. The following precis appears in the Congressional Research Service MiniBrief on "Education: Challenges in the 1980's:" [36]

> During the 1980s. various issues are likely to emerge concerning public and Federal interest in education. These issues include the extent of education to be provided at public expense; the relative share of the education fiscal burden to be borne by local, State, and Federal revenue sources; public funding for nonpublic schools; equal access to education for all students; bilingual education; national performance standards; focus on Federal programs; declining rate of growth in resources; and competition for funds among various social service programs.

The author, Dr. K. Forbis Jordan. then turns his attention to continuing developments in communications technology which, he feels, could well be the forces: [37]

> * * * that change the manner in which schools are organized and conducted. With appropriate support and leader-

[34] To Improve Learning. p. 11.

[35] MacBride. Robert. The Automated State. Philadelphia. Chilton Book Company. 1967. p. 75.

[36] U S. Library of Congress. Congressional Research Service Education and Public Welfare Division Education: Challenges in the 1980's Washington, Congressional Research Service. Minibrief number MB 79268. p. 1.

[37] Ibid. p. 7.

ship, the concept of education in the 1980s could shift from the current emphasis on institutional "schooling" to an emphasis on learning and participation characterized by decentralized learning centers to which teachers move rather than students, a 3- or 4-day week of formal instruction, work and service experience integrated into the planned educational program for students, and more extensive use of public television and video-recorders.

The significance of the problem is understood, if imperfectly and prismatically. It will fall to the Congress, Federal departments, State and local agencies, and responsible private sector components, to shape the course of future events through a reposturing of assumptions, assignments, and national goals.

OPPORTUNITIES FOR CONGRESSIONAL INITIATIVES

In the course of periodically reviewing the status of information technology as it was being applied in various educational settings, governmental and private sector organizations have come forward with recommendations which could lead to the betterment of conditions. In some instances, such advice was incorporated into legislative measures or executive directives; on other occasions it might be used piecemeal by individual school systems or local oversight groups. As has been shown, two forces were in existence and often in contraposition: one which sought to have all educational decisions reside with local jurisdictions, and a second which reflected the postulate that certain key determinations must be made at a national level.

Much remains to be done in determining how best information technology can serve education, whether in the realm of administration or instruction. Several methods of fostering ameliorative action are open to the Congress and other societal groups, but the emphasis in this section will be on possible legislative initiatives that constitute specific courses of action:[28]

1. *Introduction of new legislation*—such bills may:

Create a special study mechanism (e.g., commission or task force) to examine current user needs and responding systems and organizations.

Require the incorporation of technology-supported management techniques for the planning, management, and evaluation of education's administration and curricula.

Call for the continuing use of contractor personnel and services to augment in-house capabilities in this area.

Identify roles for various public and private sector organizations having known missions and resources that are germane to information technology and education.

Mandate the utilization, in specific activity areas, of information devices and man-machine techniques.

Provide for the creation of a special information capability, such as a clearinghouse or network, that could acquire, store, process, and make available requisite data for diverse user communities.

[28] Information Technology in Education. A Joint Workshop and Hearing. p 20, 21

2. *Review of existing legislation*—may occur as a result of individual Member action, or during the deliberations of the budget, authorization, or appropriations committees in regard to:

Adequacy of Public Law goals and provisions, from the vantage point of proven program performance.

Perceived effectiveness of present agency or department program implementation, especially as concerns cost-performance measurement (where appropriate) and hindsight assessment of initial project objectives.

Possible redirection of departmental implementation and interpretation of directives, conducted through high level executive branch (OMB) action.

3. *Analysis of sunset legislation*—past valuable initiatives, often forgotten with the passage of time, merit review lest useful analyses of the problem are lost or existing information resources and services already in place be seriously diluted or unthinkingly removed.

4. "*Jaw-boning*" (*persuasion*) *of responsible Federal executive branch departments and agencies*— the varying roles within the Federal establishment (OMB, ED, NTIA, NSF) often are diminished or become minimal over time; legislative interest often reinforces the resolve to evaluate new appropriate organizational frameworks, budgeting goals, program objectives,[39] use of technology, and the implications of applying modern technology to the needs of user groups.

5. *Utilization of legislative research and analysis capabilities*—by calling upon the extensive resources of the Congressional Research Service, Office of Technology Assessment,[40] General Accounting Office, and Congressional Budget Office (as appropriate), Congress can commission studies of varying scope and depth that then may be applied to selected congressional review or foresight activities.

As a result of such enterprises, there can be a strengthening of American education and a firming of the resolve that renewal must be a continuing process. It was in this spirit that Thomas Jefferson wrote of the essential role which citizens must fulfill, through knowledgeable involvement in their government and its many responsibilities:[41]

> I know of no safe depository of the ultimate powers of society but the people themselves, and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it away from them, but to inform their discretion.

---

[39] The Department of Education has recently awarded a contract to Cuadra Associates to develop a "Library and Information Science National Research Agenda for the 1980's".

[40] The Office of Technology Assessment has undertaken an 18-month major project which will examine the present and future roles of information technology in education.

[41] Thomas Jefferson.

[41] Dos Passos, John. The Head and Heart of Thomas Jefferson. New York. Doubleday, 1954. p. 195.

II. INFORMATION TECHNOLOGIES IN EDUCATION

The five major areas of information technology, as they relate to education—Computers, Ergonomics, Communications, Information Display, and Information Storage—merit discussion at this juncture.[42] While presenting these areas individually does not reflect the nature of the technology convergence that is occurring in the world today, such an approach does provide a better understanding of each technology's basic concepts and equipment. An annual report series entitled "Aspects of Educational Technology"[43] has attempted to address the complex issues which are of importance in instructional technology. This chapter will identify some of the most important aspects of these technologies, including the ways in which they are converging and the resultant impacts.[44]

Computers

The first area is that of computer use in education, where three main uses of computers may be defined: computers in administrative functions (finance, planning, student records, etc.), the use of the computer as an instructional tool (programmed learning, tutorials, simulation, programming, and research), and the computer as an object of study.[45] Studies performed by Dr. John Hamblen, which are known collectively as the "Hamblen Reports," are particularly useful in providing a statistical view of how computers are used in higher education.[46]

The use of the computer as an instructional tool, i.e., the computer as instructor, the computer as a laboratory, as a calculator, or as an aid to an instructor are discussed in great detail in works by Margolin and Edwards.[47] A perceptive discussion of evaluating instructional technology (primarily computer-assisted instruction) is made by

---

[42] The Fourth Revolution. Instructional Technology in Higher Education. A Report and Recommendation by the Carnegie Commission on Higher Education. New York, McGraw Hill, 1972. 110 p.

[43] Aspects of Educational Technology. The Association for Programmed Learning and Educational Technology. New York, Nichols, Annual.

[44] For those interested in examining the history of uses of technology in education, two volumes are valuable:

Anderson, Charnel. Technology in American Education 1650–1900 Washington, U.S Govt. Print. Off., 1962. 53 p.

Saettler, Paul. A History of Instructional Technology. New York, McGraw Hill, 1968. 399 p.

[45] Three volumes which provide an overview of the computer's uses in education are.

Caffrey, John and Charles Mosmann. Computers on Campus. Washington, American Council on Education, 1967. 207 p.

Rothman, Stanley and Charles Mosmann. Computers and Society. Chicago, Science Research Associates, 1976. p. 234–251.

Goodlad, John and others. Computers and Information Systems in Education. New York, Harcourt & Brace, 1966. 152 p.

[46] Hamblen, John W. and Thomas B. Baird. Fourth Inventory. Computers in Higher Education 1976–1977. Princeton, Educom, 1979. Various pagings.

[47] Edwards, Judith B. and others. Computer Applications in Instruction: A Teacher's Guide to Selection and Use. Hanover, New Hampshire, Time Share, 1978. 202 p.

Margolin, Joseph B. and Marion R. Misch. Computers in the Classroom: An Interdisciplinary View of Trends and Alternatives. Washington, Spartan Books, 1970. 382 p.

Mosmann.[48] The 1977 hearings, "Computers and the Learning Society,"[49] dealt with the use of computers in instruction and their evaluation. These works provide pertinent background material for further discussion of the primary computer configurations which are utilized in education. They point out that there have been a number of waves of enthusiasm for computers in education: the 1960's (when large mainframe computers were thought to be the solution), the early 1970's (the era of minicomputer development), and the current movement towards microcomputer use for instruction.

Each of these periods did signify times of computer acquisition by educational institutions, but none has resulted in making computer-assisted technology practical for all students. The use of mainframe computers for the often voluminous, repetitive tasks required by administration has become a relatively common solution. Minicomputers are found in schools and libraries to assist in other administrative tasks. It is the advent of low cost microcomputing or "personal computing' which has given new impetus to efforts toward wider educational usage. As Dr. Tom Dwyer of the University of Pittsburgh has pointed out, there are many questions to be answered about the concepts of information technology including: cost effectiveness, adequate software, and the high quality of printed materials.[50]

Despite the serious questions raised by Dwyer and others, people like Rothman and Mosmann discern in the role of the computer (as an instructional tool) a great hope for education which will free students from the day-to-day reality of classroom instruction:[51]

> When instruction takes place in a class, students are in lock-step with their classmates; no one can move ahead faster than the rest of the group and no one can fall very far behind. If a student has troubles keeping up, he or she receives a poor grade; those who keep ahead of the class get an A. If a student is interested in pursuing a different aspect of the subject or investigating it in greater depth he is usually not allowed to do that.

Much of the controversy over the uses of computers for instruction, as shown in Figure 2, is summarized from an article by Lou Frenzel.[52]

Dr. Ludwig Braun has made an even more succinct analysis of the reasons for the limited role that computers have played in education:[53]

The lack of high quality courseware.

A lack of training and willingness to accept computers in education.

The high cost of acquiring computers and peripheral devices.

The last of these computer uses in education is that of the computer as an object of study. A reflection of the genuine interest and concern

---

[48] Mosmann, Charles John. Evaluating Instructional Computing. University of California, Irvine, California. 1976. 88 p.
[49] Computers and the Learning Society.
[50] Dwyer, Tom. Books as an Antidote to the CAI Blues, or Take a Publisher to Lunch. Byte V. 5. July 1980 p. 74–84.
[51] Rothman, Stanley and Charles Mosmann. Computers and Society. p. 233.
[52] Frenzel, Lou. Education Forum. The Personal Computer—Last Chance for CAI? Byte, V. 5. July 1980. p. 86–97.
[53] Braun, Dr. Ludwig. Computers in Learning Environments. An Imperative for the 1980's Byte. V 5. July 1980. p. 6

FIGURE 2. Advantages and disadvantages of computer assisted instruction

ADVANTAGES OF CAI	DISADVANTAGES OF CAI
It is a good method for an individual student's instruction—pace and complexity for the person.	No firm advantage over other teaching methods.
CAI is an interesting and valid application of the computer.	Extremely expensive when compared with traditional tools. Programmed instruction is a technology with much less cost.
Marginal costs of adding CAI instruction capabilities to existing computers are quite low.	Special programming is required for the student, raising costs further.
Interaction is fast, student is part of the learning process, perhaps not more effective than traditional methods of learning, but as entertaining.	Textbooks are still preferable in terms of cost and efficiency.
	Video and other audiovisual formats are less expensive and more attractive.
	No exhaustive list of software exists.
	Lack of standards for software.

which exist today is the bill. introduced in the 96th Congress by Representative Thomas J. Downey of New York,[54] which seeks to achieve economical classroom use of computers costing less than $2,000. A more impressive example is that of the French program described by Jacques Hebenstreit in "10,000 Microcomputers for French Secondary Schools".[55] Approximately one-half of the funding of this project will be used to train teachers in the use of computers. This aspect of computer use centers upon "computer literacy," which has a two-fold meaning: that people should know how to program a computer, and that people should be aware of the basic technology of computers.

ERGONOMICS

The second major area of information technology in education involves "ergonomics," or as it is most often known, the human-machine interface. A number of important considerations may be identified: response time, courseware (or computer programs), computer languages, design considerations, and user friendliness, for example.

The first of the factors mentioned, response time, is a vital factor in human-machine interaction. If information technology is to supplement, or at least assist human-to-human instruction, then it must closely approximate actual human-to-human interaction. It is generally believed that when machine response time is longer than three or four seconds, the user tends to become distracted to such an extent that learning is impeded.

One of the most recurrent themes in educational technology is the lack of good educational programs or "courseware". The reasons for this are readily evident. The more sophisticated computer programs,

[54] H.R. 7459, 96th Cong., 2d Sess., 125 Cong. Rec 4333 (1980).
[55] Hebenstreit, Jacques. 10,000 Microcomputers for French Secondary Schools. Computer. V. 13, July 1980. p. 17–21.

using the techniques of artificial intelligence, may require up to 10,000 hours of programming time for each hour of finished program. Another problem in courseware is that most educational programming is not being written by subject specialists. Rather, programmers are creating subject courseware in fields where they have little knowledge or experience. The solution to this problem is to provide the funding and opportunity for teachers or subject experts, which will allow them to learn how to write programs.

A related set of problems is caused by computer languages. If funding is to be provided to teachers for the study of computer programming, planners must realize that such support should not be limited to once-in-a-lifetime training. Edwards describes the different aspects of this problem: the basic programming languages, the use of author languages for writers, and special languages required for other electronic devices.[56] The quandary caused because there are so many different types of computers, which require different programming skills and languages, is somewhat improved by modern compiler languages—such as PASCAL[57] and FORTH,[58]—and there will continue to be improvements in languages and software which will require the periodic retraining of programmers. Direct English language programming of computers, and other forms of voice interchange rapidly becoming possible, will alleviate many of these problems.[59]

However, human-machine compatibility is only partially based upon conversational exchanges. Purely mechanical problems may relate to design needs. Factors as seemingly inconsequential as the shape of a terminal, the means of data entry, and transportability have been shown to be tremendously important.[60] In Europe, where computer operators seem to have a greater say in the shape of the machinery, certain features may be mandatory under the law.[61] Sweden, for example, now requires that CRT screens be orange, a color which causes less operator eye fatigue. There are a number of other questions which should be asked about some of the readily accepted tools of information technology, as shown by the recent controversy over carcinogenic photocopying materials.[62]

COMMUNICATIONS

The third area of information technology in education is that of communications technology. An examination of the chronology in Chapter III shows that both the Congress and the private sector have made repeated efforts to examine and predict the effects of communications implementation upon education. Of particular concern have

[56] Edwards, Judith B. Computer Applications in Instruction. p. 14–30.
[57] Jensen, Kathleen. PASCAL. New York, Springer Verlag, 1975. 167 p.
[58] Moore, Charles H. The Evolution of FORTH, an Unusual Language. Byte, v. 5, August 1980, p. 76–92.
[59] Kaplan, Gadi. Word Into Action 1. IEEE Spectrum June 1980, v. 17, 1980, p. 22–26.
[60] Winkler, Connie. Ergonomics Focus Seen Vital to System Design. Computerworld, v. XIV, October 12, 1980, p. 8.
[61] Dooley, Ann. Human Factors Challenging Terminal Vendors. Computerworld, v. XIV, August 11, 1980, p. 8.
[62] A series of articles on this issue may be found in Computerworld issues dated September 8, 15, 22, 1980.

been television, cable systems, and satellites. Each new generation of these technologies has engendered a wave of enthusiasm for the possible benefits which could be realized for education, but these are often followed by periods of disappointment when such great hopes were not fulfilled. Not surprisingly, there has been some cynicism on the part of the educational community regarding claims for new communications technologies, such as fibre optics and direct broadcasting by satellite. Two current projects in other countries demonstrate that there is justifiable hope that these new technologies will be the answer to many of the problems in education.

Project Ida, the ongoing telecommunications experiment in the Manitoba Province of Canada, will be one of the first attempts to experiment with the concept of the "wired city".[63] One of the areas of experimentation will be the provision of education in the home via interactive cable. Another related experiment is making use of fibre optics to provide communications for rural areas. The BS series of satellites launched by NASA for the Japanese Ministry of Posts and Telecommunications are to be the basis for a number of experiments which will focus upon direct broadcasting by satellite to homes. A .6 meter satellite reception antenna or dish has been devised which makes new applications of this sort practical. Part of the BS satellite experiments will deal with the broadcast of educational television to remote islands of the Japanese archipelago.[64] Figure 3 lists some of the other experiments in the field of satellite communications which are at least partially concerned with education. Of special interest in the area of communications are two sets of hearings held by the Subcommittee on Communications of the U.S. House of Representatives and by the Senate Subcommittee on Communications.[65]

Resolution of the problems of high cost and complexity in communications is necessary if any of today's advances in the other areas of information technology are to be made available for educational purposes. The efforts to solve these problems are currently being concentrated in three areas: improvement of data handling technology (circuit and packet switching), networking (linking of data processing and handling), and the development of new transmission media.[66] Education is especially hindered by the lack of interactive communications which would allow many changes in our formal process of education: home education, resource sharing, and videoconferencing, to name a few.

---

[63] Exploring the Wired City. Manitoba Telephone System. 1980. 17 p.

[64] Material extracted from the speech of F. Yamashita, Chief Research Official, Space Communications Development Division, Japanese Ministry of Posts and Telecommunications, at the Fifth Annual Conference on Satellite Communications for Public Service Held at the Washington Hilton Hotel, October 8–10, 1980.

[65] U.S. Congress. House. Committee on Interstate and Foreign Commerce. Subcommittee on Communications. Hearings. Telecommunications Facilities and Demonstration Act of 1975. Washington, U.S. Govt. Print. Off., 1975. 138 p.

U.S. Congress. Senate. Committee on Commerce, Science, and Transportation. Subcommittee on Communications. Hearing. Rural Communications. Washington, U.S. Govt. Print. Off. 1977. 138 p.

[66] Extracted from the Remarks of Morris Edwards, Program Chairman of the Federal Computer Conference and data communications consultant to Communications News and Infosystems, at the 1980 Federal Computer Conference, held at the Washington Sheraton Hotel, September 22–24, 1980.

FIGURE 3.—Telecommunications experiments in education

COUNTRIES INVOLVED	SUBJECT
Australia/U.S.	Provision of Cable Network News, Home Box Office.
The Peoples Republic of China/U.S.	Satellite conference involving Capital Children's Museum and counterpart in The PRC.
Senegal/U.S.	Agency for International Development is hoping to improve telephony and education for rural areas of the country.
Sweden/U.S.	Swedish libraries will be linked to data-bases in the US to access bibliographic information.
University of the West Indies (Jamaica) and University of the South Pacific	Mutual exchange of information and educational programming.
U.S./Appalachian Community Service Network	The provision of television programming beneficial to an economically deprived audience; continuing education, community service, and professional development programming.

INFORMATION DISPLAY

Another technology which has a primary role in education is that of information display, sometimes called computer graphics. In its most simple configuration this might refer only to graphics or audio-visual displays. At the other end of the spectrum are interactive, real-time (i.e., they react in less than a second), three-dimensional simulations which are accompanied by music or conversation. The vast majority of these materials, however, are made up of slides, transparencies, film and filmstrips, television, records, cassettes, tapes, and printed matter.

The subject of educational media, those methods used currently in education, is enormously complex. A very broad treatment of this field may be found in Sleeman and Rockwell's anthology.[67] Other, more timely issues in media are dealt with in the annual by Bowker, entitled *Educational Media Yearbook* (now in its fifth edition),[68] which also provides a comprehensive index and bibliography. A valuable work on the topic of the costs of educational media—cost analysis theory and experience in case studies—is Jamison's *The Costs of Educational Media*.[69] Philip Sleeman has written *Instructional Media and Technology*, a handbook for those actually studying the field or wanting "how to" advice.[70] Finally, for those seeking materials, the

[67] Sleeman, Philip and D. M. Rockwell. Instructional Media and Technology: A Professional's Resource. Stroudsburg, Penn., Dowden, Hutchinson, and Ross, 1976. 401 p.
[68] Brown, James W., ed. Educational Media Yearbook 1978. New York, Bowker, 1977. 433 p.
[69] Jamison, Dean T. The Costs of Educational Media. Guidelines for Planning and Evaluation. Beverly Hills, Sage, 1978. 255 p.
[70] Sleeman, Philip J. Instructional Media and Technology. A Guide to Accountable Learning Systems. New York, Longman, 1979. 374 p.

preeminent collector in the field is the National Instructional Center for Educational Materials (NICEM), which produces indices of audiovisual materials that are available.[71]

The principal medium of information display in education over the past two decades has been television. A study performed for The Carnegie Commission and entitled *A Public Trust* provides an excellent overview of educational television and the role that public broadcasting should play in American life.[72] An earlier report by The Ford Foundation examines the role of television as an instructional medium.[73] The emphasis of educational broadcasting today, however, seems to be focusing upon the twin issues of programming and finances.

It is the newer uses of television or the cathode ray tube (CRT), and other innovations in media—TV, videodisc, and computer combinations, for example—that were of most concern in both the October 1979 and April 1980 hearings. Primary interest in educational media is now being placed on developments in display techniques. Some of these display techniques, such as Control Data Corporation's PLATO,[74] and TICCIT, have been in use for 15 or more years. Videodisc technology made an impressive showing in both the hearings and in the technology workshop, but represents a storage media (the next section to be discussed) and not a display capability.

Computer graphics were constantly alluded to, but that generic term was avoided, perhaps because of the concern that its proper name would connote technocracy. Computer graphics is the name for those graphic techniques which perform such seemingly trivial tasks as teaching geometry to children,[75] animating displays on CRTs or television, and providing for three-dimensional simulation. The graphics' capabilities available for computer-assisted instruction were until recently rather primitive and the problems many.[76] A brief, but excellent history of the use of computer graphics in education may be found in an article by Richard S. Simmons, which also examines the growth and needs of computer-assisted instruction in general.[77]

The role of computer graphics in education is similar to that of computers in education, in that graphics are a technology, a method of instruction, and are also an object of study. As a technology, graphics are transparent to the user, a method by which a subject of study is depicted and made available in hardcopy form. As a method of instruction, computer graphics are a subfield of computer-assisted instruction, with most of the characteristics of CAI. As an object of

[71] The National Information Center for Educational Media is located at the University of Southern California, in Los Angeles. NICEM makes available an on-line data base of items and 14 printed indices of audiovisual material. The Center also attempts to evaluate the material that it indexes.

[72] A Public Trust. The Report of the Carnegie Commission on the Future of Public Broadcasting. New York, Bantam 1979. 401 p.

[73] An Inquiry into the Uses of Instructional Technology. A Ford Foundation Report New York, The Ford Foundation, 1972, p. 21–49.

[74] An informative description of the PLATO system may be found in an article by Stanley G. Smith and Bruce Arne Sherwood. Educational Uses of the Plato Computer System. In "Electronics. The Coming Revolution." Washington. American Association for the Advancement of Science, 1977, p. 68–75.

[75] Papert. Seymour. New Cultures from New Technologies. Byte. v. 6, September 1980. p. 230–240.

[76] Licklider. Dr. J.C.R. "The Role of Computer Graphics" in: The Computer Utility. Implications for Higher Education. Michael A. Duggan, Ed. Lexington, Mass., D. C. Heath Co., 1970, p. 11–16.

[77] Simmons. Richard S., Ph.D. An Overview of Computer Graphics in Education and Training. Computer Graphics World, v. 3. May 1980. p. 32–37.

instruction, graphics are considered part of the subject of computer science. It may be said that computer graphics are one of the most important parts of computer technology with a role in the educational systems of the future. A thorough treatment of this subject is found in a recent CRS report: "Computer Graphics: Applications and Technology."[78]

Some aspects of computer graphics technology which are crucial for the future of information technology in education include:

The development of equipment which is used in the production of hard copy (slides, transparencies, and printed matter).

The development of equipment which is used for the input of data into computer storage (scanners and digitizers).

The development of new display techniques which will enhance the use of computers in education (display processing).

The development of display technologies which will improve upon the cathode ray tube (flat panel and portable displays).

INFORMATION STORAGE

Another area of information technology's application to education is information storage. In general, one fact should be pointed out about this application. while the cost of computers and processing information has decreased, the cost of storage has remained rather high. The cost of gold and cobalt (used in circuit connections and in "read-write" head mechanisms respectively) have increased dramatically when compared to the silicon used in metal oxide silicon technology.[79] While the Japanese seem to be developing a solution to this problem, there is no immediate answer in sight for U.S. manufacturers.

Figure 4 portrays the different types of technology available and the relative amounts of their information storage capacity.[80] While it seems that the book scores low on the scale of storage media, the all important feature of cost that was noted in the first section should be remembered. The book. for all of its frailty and lack of various types of access, is still a cost-effective method for providing information. In terms of the use of any storage medium for schools the book remains the only viable alternative for providing instruction and reading material. All other proposals to date based upon access to digital storage media are only practical if costs could be lowered through an economy of mass scale.

It must be remembered that no single medium will answer all of the needs of education. If the crucial factor for selection is the ability to hold the greatest amount of digital data then four major types may be identified: magnetic disk, magnetic tape, floppy disk, and optical or digital videodisc.

(1) *Magnetic disk.*—The magnetic or hard disk has shown continuing promise over the years with constant increases in the amount

[78] Chartrand, Robert, Jerry Borrell, and Jean Paul Emard. Computer Graphics: Applications and Technology. Washington, Congressional Research Service. 1980. 135 p.

[79] Information Systems News. Gold, Cobalt Problems May Mean Costlier Computers. Jan. 14. 1980, p. 9.

[80] Business Week. Videodisc: A Three Way Race for a Billion Dollar Jackpot. July 7, 1980, p. 80.

FIGURE 4.—*Comparison of memory device capacities*

Memory Device:	Storage capacity (millions of characters)
Human brain	125,000,000,000
National Archives	12,500,000,000
IBM 3850 magnetic cartridge	250,000,000
Encyclopédia Britannica	12,500,000
Optical disc memory	12,500,000
Digital Disc	2,000
Magnetic (hard) disk	313
Floppy Disk	2.5
Book	1.3
Bubble chip	.2
Semiconductor chip	.003

of data that can be stored, size reduction of the unit, and the speed of access to information. One development in particular has been of great importance to this medium: the IBM-developed "Winchester" technology. The two features of value in this method are: the use of sealed containers for the storage disk and an "air bearing" effect which prevents the read-write head from touching the surface of the disk.[81]

An interesting trend in disk storage is the recent use of Winchester type technology in a small removable cartridge device.[82]

(2) *Floppy Disk.*—The basic mechanism of the floppy disk is the same as that of the hard disk except the production material and the way in which data are read from the disk. "Floppies" are most often constructed from a thin sheet of mylar plastic. Unlike Winchester technology, the read-write heads actually touch the disk, which causes troublesome wear of the recording surface and errors when the head hits small dust particles. Because the disks are soft they must rotate at speeds much lower than hard disks or centrifugal rotation would deform the disk and alter data. However, floppy disk technology is relatively new (introduced by IBM in 1973) and improvements, such as the ability to access data on both sides of the disk, portend greater benefits.[83] Advantages of the floppy disk as a storage medium for instructional purposes include: relatively low cost, transportability, simple technical requirements, and compatability with mini- and microcomputers.

(3) *Magnetic Tape.*—Tape storage of digital data is one of first media to be developed and today remains one of the least costly means for storage. Until recently, work in the hard and floppy disk storage areas seemed to be relegating tape technology to a rapidly diminishing role in information technology. Factors such as slow access to data, large size of the physical unit, maintenance problems, and destruction of the tape by the recording mechanism outweighed the initial low cost of tape units. Recent "streaming" techniques have made the use of tape economically viable again. A number of other factors such as improvement of read/write heads, microprocessor controlled tape transports, and more efficient recording formats are also playing a role in the revitalization of tape storage. Tape will probably play a some-

[81] White, Robert M. Disk Storage Technology. Scientific American, v. 243, Aug 1980, p 138–148.
[82] Pettebone, Tom. A. Removable Lynx. Mini-Micro Systems, v. XIII. Oct 1980 p. 132–134.
[83] Valentine, Pamela. A Beginner's Guide Understanding Floppy Disks. On Computing, v. 2, Summer 1980. p. 8–15.

what different role in this configuration since it is expected to primarily support or be used to complement disk technology.[84]

(4) *Optical and Digital Videodisc.* The commercial market for videodisc technology is so potentially lucrative (primarily in entertainment) that most of its benefits are being obfuscated. Current technology can allow us to store up to 2 gigabytes (billion) characters on a single digital disc. If one calculates this capacity on the basis of a 1 million character average for a single monograph or volume, one disc could hold about 2,000 volumes.[85] Even larger amounts of data stored in this format may be possible.[86] There are three formats for data storage on discs:

(1) Videodisc—the imprint of standard NTSC video images on a disc.

(2) Optical digital disc—data are encoded onto a standard video signal.

(3) Digital disc—data are encoded onto a disc by the use of a laser which can burn pits into the disc's surface.

The applications of each of these three may differ. The videodisc method is currently being used primarily for the entertainment industry—sales of movies on discs being the primary use. The digital disc is most often thought of as a device for mass storage. Recent work by the Phillips Company will allow disc encoding *in situ*, thus providing a cheap, massive storage medium which will rival even a floppy disk. An example of this technology is being marketed by Bell & Howell and is directed toward an education market. The Bell & Howell product combines the Apple II microcomputer and video discs to provide random access for training programs.

Richard Atkinson and Joseph Lipson of the National Science Foundation summarize their paper on these areas of information technology with the following:[87]

> It is clear that plans can be developed for a wide variety of instructional technology futures. We can assemble affordable home learning centers based on the technologies discussed. But do we know enough to assure that they will be used effectively? Similar questions can be raised regarding the introduction of computer-based instructional technologies in the school. Our experience with television should give us reason for concern; we are still trying to understand the impact of TV on psychological development. How will the interactive nature of computer-aided instruction affect cognitive and emotional growth?
>
> Another factor that limits our vision is our tendency to be trapped in images from the past. New technologies initially imitate old technologies (e.g., the horseless carriage). Only through imaginative efforts can new forms and techniques

[84] Streaming Tape Improves Backup. Electronic Design. v. 22, Oct. 25. 1979. p 48–54.

[85] Goldstein. Charles Optical Videodiscs Potential Impact on Libraries and Online Services. Washington. National Library of Medicine. (unpublished) p. 9.

[86] Savage. Maria. Beyond Film. A Look at the Information Storage Potential of Videodiscs. Washington American Society for Information Science. v. 6. Oct. 1980. p. 26–29.

[87] Atkinson, Richard C. and Joseph Lipson Instructional Technologies of the Future. Presented at the 88th annual convention of the American Psychiatric Association in Montreal, Canada. September 3. 1980. p. 24–25.

evolve that capitalize on the unique capabilities of the new technology (e.g., the long evolution of film as an art form). While computers may offer us inexpensive texts and videodiscs may offer us inexpensive slides, surely these are intellectually trivial images of the new technology. What unique features offer us the opportunity to transform the intellectual and instructional landscape?

In order to begin thinking about these questions, a description of configurations of instructional technologies is in order. The array of hardware and software capabilities constitute the creative elements for the instructional author. They can be combined to produce many new forms. In the same way that dictionaries, novels, encyclopedias, posters, etc., are useful terms to describe the manifestations of the print technology, we need to describe some of the unique ways that the elements of the new technologies can be configured for learning. Typically, each configuration will involve a complex combination of hardware and software elements and will imply a distinctive style of interaction between the student and the system. The challenge to the instructional developers will be to invent, develop, and implement new formats that will realize the potential of the new technologies.

III. CHRONOLOGY OF SELECTED EVENTS AND LEGISLATIVE ACTIONS[88]

To place in perspective the current and potential roles of certain innovative technologies—especially computers, telecommunications, teaching machines, radio, and television—a selective review of significant events, pertinent legislation, and milestone reports that reflect their evolution and utilization in education during the past quarter century is presented.

1956.—Schools in Hagerstown, Maryland begin to receive the first cable transmissions of instructional television.

1958.—The National Defense Education Act (P.L. 85–865) [as amended by P.L. 88–210] and the Instructional Media for Handicapped Children Act (P.L. 85–905) [as amended by P.L. 89–258, as further amended by P.L. 90–247, title I] are signed into effect.

1960.—The New England Educational Data System (NEEDS) program begins on a modest basis as the Data Processing Project of the New England School Development Council.

PLATO I experiments in computer-assisted drill and practice and tutorial programs begin at the University of Illinois.

1962.—After a joint convention of State educational data processing specialists, the California Educational Data Processing Association (CEDPA) is founded.

1963.—The Council of Chief State School Officers establishes a Commission on Educational Data Systems (CEDS) to conduct studies, formulate recommendations, and plan for development on behalf of all State Departments of Education.

The Mental Retardation Facilities and Community Mental Health Centers Construction Act (P.L. 88–164) [as amended by P.L. 89–105, as further amended by P.L. 90–247], the Higher Education Facilities Act (P.L. 88–204) [as amended by P.L. 90–575, title VI], and the Vocational Education Act (P.L. 88–210) [as amended by P.L. 90–576] are passed.

The Institute for Mathematical Studies in the Social Sciences at Stanford University begins a laboratory program of research and development on computer-based instruction that receives funding from NSF and the Carnegie Corporation.

1964.—EDUCOM (Inter-University Communications Council) is founded to promote cooperative efforts in the application of computing and information technology in higher education.

1965.—The White House Conference on Education is held and its final report, *A Milestone for Educational Process*, is published.

---

[88] Based on an earlier chronology prepared by Jean Paul Emard for Information Technology in Education: A Joint Hearing and Workshop, p. 206–209.

The Elementary and Secondary Education Act (P.L. 89–10 [as amended by P.L. 90–247, as further amended by P.L. 91–230] and the Higher Education Act (P.L. 89–329) [as amended by P.L. 90–35] are signed into law.

The Educational Resources Information Center (ERIC) system begins operation with the production and dissemination of the *Catalog of Selected Documents on the Disadvantaged.*

1966.—The Joint Economic Committee holds hearings on "Technology in Education," followed by the publication of the committee print, *Automation and Technology in Education.*

The Library Services and Construction Act (P.L. 89–511) and the Adult Education Act (P.L. 89–750) are enacted.

The National Information Center for Education Media founded.

1967.—The President's Science Advisory Committee issues its report on computers in higher education.

The Model Secondary School for the Deaf, utilizing the latest technologies for educational and other purposes, is established by P.L. 89–694 on the campus of Gallaudet College.

1968.—President Johnson appoints a Commission on Instructional Technology.

The House Committee on Government Operations releases its report, "Operation of Office of Education (Conflict of Interest—Proposed Grant for Computerized Classroom)," examining the intended implementation of education technology.

The Association for Development of Computer-based Instructional Systems (ADCIS) is founded in order to advance and promote computer-assisted or managed instruction at secondary and higher education levels.

"Sesame Street" (and "The Electric Company" in 1972) begins to receive funding from the Office of Education under the Cooperative Research Act (P.L. 83–351).

1969.—The first Conference on Computers in Undergraduate Curricula is held at the University of Iowa.

The U.S. Department of Defense Advanced Research Projects Agency (ARPA) establishes a computer networking configuration called ARPANET, commencing with four Western universities.

The House Committee on Education holds hearings on the "Needs of Elementary Education for the Seventies".

The National Center for Media and Materials for the Handicapped Act (P.L. 91–61) authorizes the creation of a media and materials center utilizing varied technologies and applications for the handicapped.

The House Subcommittee on Select Education holds hearings on the Educational Technology Act of 1969.

The General Services Administration directs the National Archives to establish the National Audio Visual Center in Washington, D.C.

John Hamblen, under NSF contract, produces the first *Inventory of Computers in U.S. Higher Education, 1966–1967* that provides a comprehensive statistical base of usage, types of use, and expenditures on computers in higher education.

1970.—The House Committee on Labor and Public Welfare holds hearings on the Higher Education Amendments of 1970.

The House General Subcommittee on Education releases "A Compendium of Policy Papers" on the needs of the elementary and secondary education for the seventies.

The National Commission on Libraries and Information Science is established by P.L. 91-345.

The final report of the Commission on Instructional Technology, *To Improve Learning*, is issued as a House Committee on Education and Labor committee print.

The House Committee on Science and Astronautics holds the eleventh meeting of the Panel on Science and Technology, resulting in publication of the report entitled "Management of Information and Knowledge."

The House Committee on Foreign Affairs, (Subcommittee on National Security Policy and Scientific Developments) holds hearings on the "Foreign Policy Implications of Satellite Communications," during which the value of satellites for providing education to the LDC's is mentioned.

Amsterdam is the site of the 1st World Conference on Computer Education.

1971.—The House Subcommittee on Select Education receives testimony on the establishment of a National Institute of Education.

A publication of selected references on new technologies in education is issued by the House Committee on Science and Astronautics.

The National Science Foundation grants funding for the development of two computer-assisted teaching systems, PLATO IV of the University of Illinois and TICCIT of The MITRE Corporation.

1972.—The Carnegie Commission on Higher Education releases two major studies, *The Fourth Revolution: Instructional Technology in Higher Education* and *The Emerging Technology: Instructional Uses of the Computer in Higher Education* (in conjunction with The Rand Corporation).

The National Institute of Education is established as a quasi-governmental body and a National Center for Educational Technology is established within the Office of Education.

Hearings on educational technology are held by the House Select Subcommittee on Education (e.g., H.R. 4916).

The Emergency School Aid Act (P.L. 92-318, Title VII) authorizes the development and use of new curricula and instructional methods, including the acquisition of any instructional materials and technologies, for use by all children regardless of race, color, or economic standing.

1973.—The Ford Foundation publishes *An Inquiry into the Uses of Instructional Technology.*

The MITRE Corporation publishes a study on its Reston, Virginia experiment involving the technical and economic considerations attendant on the home delivery of instructional and other socially related services via interactive television.

Issues and public policies in educational technology are discussed in the National Academy of Engineering's report, *To Realize the Promise.*

Demonstration of PLATO is a featured presentation at hearings on Federal information systems, plans, and the development of advanced information technologies held by the House Subcommittee on Foreign Operations and Government Information.

The House Subcommittee on the Handicapped holds hearings which include discussions of the area of computer-assisted instruction.

1974.—Under the Education Amendments of 1974 (P.L. 93-380), (1) the Commissioner of the Office of Education is empowered to use, at his discretion, certain funds for educational television; and (2) the Office of Library and Learning Resources is created to administer all funding and oversight of those technologies used for instructional programs.

1975.—*Computers and the Learning Process in Higher Education* is prepared for The Carnegie Commission on Higher Education.

The House Subcommittee on Communications holds hearings on the Telecommunications Facilities Act of 1975, H.R. 4564, with the "Use of Educational Broadcasting" a focal point.

The Education for All Handicapped Children Act (P.L. 94-142) is passed.

1976.—The Educational Testing Service and Los Angeles Unified School District initiate a National Institute of Education funded, four-year project in Los Angeles, "Taking a Long Hard Look at Computer Assisted Instruction".

The Educational Professions Development Act (P.L. 90-35) is amended by the Teacher Corps and Teacher Training Programs Act (P.L. 94-482).

1977.—The Senate Subcommittee on Communications holds hearings on Rural Telecommunications in which educational broadcasting is discussed.

1978.—Title II of the Education Amendments of 1978 (P.L. 95-561) stresses the need to utilize new technologies to improve and develop basic skills and Title XV grants assistance for children's educational television.

"Computers and the Learning Society" is the theme of the hearings and the subsequent committee print (1978) of the House Subcommittee on Domestic and International Scientific Planning, Analysis and Cooperation.

1979.—The first National Educational Computing Conference is convened at the University of Iowa.

The landmark report of The Carnegie Commission on the future of public broadcasting, entitled *A Public Trust*, is published.

The final report on *Videoconferencing via Satellite: Opening Congress to the People* is published, detailing certain educational uses of this conferencing technique.

The American Federation of Information Processing Societies (AFIPS) convenes a panel to study the scientific and technical implications of information technology in education.

The House Subcommittee on Science, Research and Technology holds hearings on "Information and Communications Technologies Appropriate in Education (including H.R. 4326)".

The White House Conference on Library and Information Services is held in Washington, D.C.

The Department of Education is established (P.L. 96-88) and the first Secretary of Education sworn in on December 6, 1979. An Assistant Secretary for Educational Research and Improvement is created to pursue research, development, dissemination, and assessment.

1980.—The House Subcommittee on Science, Research and Technology, the Senate Subcommittee on the Handicapped, and the Congressional Research Service jointly sponsor a three-day series of panel/workshops on the "Application of Technology to Handicapped Individuals" with a subsequent 1980 committee print.

The American Association for Higher Education establishes a center for learning and telecommunications which will assist post-secondary institutions in exploring technology-based programs.

The Lister Hill Center of the National Library of Medicine announces the release of a mini-computer based, "stand alone" educational system as part of its program on "Computer Based Educational Technology."

Joint Hearings are held before the Subcommittee on Science, Research and Technology of the Committee on Science and Technology and the Subcommittee on Select Education of the Committee on Education and Labor, House of Representatives on April 2, 3, 1980.

The House Committee on Education and Labor's Subcommittee on Elementary, Secondary, and Vocational Education issues "A Compendium of Policy Papers, Needs of Elementary and Secondary Education in the 1980's."

IV. SALIENT CONGRESSIONAL ACTIVITIES (1969–1980)[89]

Congressional exploration of the potential for education of various technologies has spanned more than 20 years, but it was not until the 1969–1980 period that the full force of attention to this area of growing concern was evidenced on Capitol Hill. Not only were several congressional committees and subcommittees active in considering the merits of specific legislation dealing with information technology in education, but in other instances they sought to collect expert testimony regarding the present status and projected value of such devices, techniques, and systems.

One iterative pattern, also reflected in the previous decade, found the Congress reviewing its earlier work which had resulted in public laws that must now be modified. These adjustments, executed only after intensive scrutiny (hearings, studies), were responsive to changing needs of various constituent groups or the introduction of advanced technologies which could offer yet further support for educational administrators and instructors.

The focus of this chapter will be the endeavors of the past six Congresses (91st through the 96th), with particular attention to oversight hearings, special seminars, and studies which were designed to garner useful factual information and the insights of various categories of professionals with responsibilities in the area: government administrators, academic representatives, corporate and foundation officials, and other knowledgeable "experts." The burden of investigation in the House of Representatives during this period was shared by several legislative entities, especially the Committee on Education and Labor and the Committee on Science and Technology. In the Senate, special reviews touching on this subject were conducted by such groups as the Committee on Labor and Public Welfare and the Committee on Commerce, Science, and Transportation. A listing of committees and submittees in both Chambers involved with the role of informaton technology appears as Figure 5.

FIGURE 5.—List of congressional committees and subcommittees involved with information technology in education

HOUSE OF REPRESENTATIVES

Committee on Education and Labor
- General Subcommittee on Education
- Select Subcommittee on Education
- Subcommittee on Education
- Subcommittee on Elementary, Secondary, and Vocational Education
- Subcommittee on Select Education

[89] Quoted testimony for each of the subsections found in this chapter is attributed to the source document.

Committee on Foreign Affairs
  Subcommittee on National Security Policy and Scientific Developments
Committee on Interstate and Foreign Commerce
  Subcommittee on Communications
Committee on Labor and Public Welfare
  Subcommittee on Education
  Subcommittee on the Handicapped
Committee on Science and Astronautics
  Subcommittee on Science, Research and Development
Committee on Science and Technology
  Subcommittee on Domestic and International Scientific Planning, Analysis, and Cooperation
  Subcommittee on Science, Research, and Technology

SENATE

Committee on Appropriations
  Subcommittee of the Committee
Committee on Commerce, Science and Transportation
  Subcommittee on Communications
Committee on Labor and Public Welfare
  Subcommittee on the Handicapped

The continuing evolution of the focal technology and its varied impacts are evident throughout the testimony and supporting documentation for this period. The emphasis shifts from commentaries about the utility of audiovisual devices and materials in the earlier years to expositions on the proven performance and promise of computer and telecommunications technologies in the late 1970's.

Underscoring the role of information technology in education on several occasions was Representative John Brademas, who chaired three series of hearings; on one occasion he stressed that: [90]

> * * * the intelligent and effective use of instructional technology could multiply the effectiveness of teachers and of the facilities in which they teach, and that the intelligent application could raise the quality of instruction, could increase access to education, and that those were the two principal justifications for increasing our investment in instructional technology.

Again and again the formal testimony and advice offered during dialogues between witnesses and Members of Congress stress the need to exercise caution in the introduction of advanced technology into the learning environment. In most cases, these comments seemingly do not arise from a disbelief in the utility of many of the new devices and man-machine techniques, but are more related to the difficulty of integrating innovation into any traditional setting. The essence of this

---

[90] U.S Congress. House Committee on Education and Labor. Select Subcommittee on Education Educational Technology Act of 1969 Hearing, 91st Congress, 2d session. Held Mar. 12, 1970. Washington, U S Govt. Print. Off., 1971, p. 60. (Hereafter cited as Educational Technology Act of 1969.)

difficulty is encapsulated by Emmanuel G. Mesthene, Director of the Harvard University Program on Technology and Society: [91]

> Technological devices already introduced into schools in recent years have had only peripheral impact, partly because educational technology is as yet much more primitive than is generally appreciated, so that fragile, unreliable, and expensive devices often gather dust in a classroom corner after an initial wave of enthusiasm has subsided.
>
> Knowledge about how to apply the technology is even more primitive, in a number of respects. Even when machines work and classroom attitudes are attuned to their use, attempts to graft the new techniques to old curriculums have proved spectacularly unsuccessful and largely unrelieved as yet by imaginative technical and curriculum innovation tailored to the new demands and possibilities of education.

A matrix setting forth the essential elements of information regarding the significant congressional activities, 1969–1980, comprises Appendix 1. A listing of public laws featuring provisions which directly or tangentially deal with the role of information technology in education, or rationally related topics, is found in Appendix 2.

The following sequential subsections are concerned with those congressionally sponsored activities—on a Congress-by-Congress basis—which serve as a backdrop for the 1979–1980 hearings that are treated in detail in Chapters V, VI, and VII.

Hearings on the Needs of Elementary and Secondary Education for the Seventies (91st Congress)

The first major event in this chronicle of congressional happenings was a series of hearings on the "Needs of Elementary and Secondary Education for the Seventies," under the aegis of the General Subcommittee on Education of the House Committee on Education and Labor.[92] Representative Roman C. Pucinski, the Subcommittee chairman, presided over six days of hearings during October and November of 1969. Related legislation involved a series of bills "to provide for the needs of elementary and secondary education for the seventies:"

- H.R. 517, the Elementary and Secondary School Construction Act
- H.R. 776, the Schoolchildren's Assistance Act
- H.R. 9866, the National Education Policy Act
- H.R. 10833, the General Education Assistance Act
- H.R. 11546, the Nationwide Educational Excellence Act

The initial hearing, perhaps more than any other, focused on the development and use of beneficial and innovative teaching techniques, the imaginative utilization of various instructional aid devices, and the necessary interaction between well trained instructors and their equipment. Among the witnesses were:

---

[91] Educational Technology Act of 1969. 184 p.

[92] U S Congress. House. Committee on Education and Labor. General Subcommittee on Education. Needs for Elementary and Secondary Education for the Seventies Hearings, 91st Congress, 1st session. Washington, U.S. Govt. Print. Off., 1969. 604 p. Held Oct. and Nov. 1969 (Hereafter cited as Needs of Elementary and Secondary Education).

Dr. Herbert Klausmeier, Director, Wisconsin Research and Development Center for Cognitive Learning—described the "Patterns in Arithmetic" television project, funded by the Cooperative Research Act (P.L. 83–351), and urged the "total system" approach.

Mrs. Joan Ganz Cooney, Director, Children's Television Workshop, National Educational Television—stated the objectives of the television workshop, and the critical experimental question: "Can the techniques proven successful in commercial television be adapted to the teaching of preschool children?" The "Sesame Street" experience was described and discussed.

In connection with these hearings, a thought-provoking study by Dr. Leon H. Keyserling, President of the Conference on Economic Progress, entitled "Achieving Nationwide Educational Excellence: A Ten-Year Plan to Save the Schools," was incorporated into the hearings documentation after being discussed at length. Another focal writing, 'Can Television Really Teach?" by Edward L. Palmer, is included as Appendix 3.

Hearing on the Educational Technology Act of 1969 (91st Congress)

The following year, the Select Subcommittee on Education of the House Committee on Education and Labor convened a hearing (March, 1970) to discuss the Educational Technology Act of 1969.[93] Representative John Brademas chaired this one-day session which was oriented to the content and ramifications of H.R. 8838, a bill "to improve educational quality through effective utilization of educational technology." This hearing was the first to be dedicated, during this decade, to the role and impacts of technology in education. A concomitant objective of this hearing was to review the findings of the Commission on Instructional Technology, commissioned in 1968 by the Department of Health, Education, and Welfare "to construct a comprehensive study of school uses of television, radio, and allied instructional media."

In reporting on the Commission report, *To Improve Learning*,[94] its chairman, Dr. Sterling M. McMurrin, Dean of the Graduate School of Education, University of Utah, noted that 2,000 persons and agencies had been contacted, regional meetings held, and eventually four guidelines developed which governed the endeavor:

We undertook to face the problems of instructional technology in terms of the learner.

We were concerned with the whole gamut of the learning process. and what must take place in the schools.

We were concerned with the whole field of education, from the preschool period through continuing education beyond graduate and professional schools.

We were concerned with the problems of instructional technology from the standpoint of instruction and learning as a whole rather than simply as individual instructional techniques.

The six recommendations of the Commission, which reflected how it "weighed future promise against present achievements, and examined

[93] Educational Technology Act of 1969, p. 62.
[94] Educational Technology Act of 1969, p 41.

the 'iscrepancies between the science-fiction myths of instructional technology and the down-to-earth facts," using as a starting point "not technology, but learning," constitute Appendix 4.

One focal point of particular value to the hearing sponsors, and subsequent congressional overseers, was the fulsome definition of "instructional technology," which merits inclusion here:

> Instructional technology can be defined in two ways. In its more familiar sense, it means the media born of the communications revolution which can be used for instructional purposes alongside the teacher, textbook, and blackboard. In general, the Commission's report follows this usage. In order to reflect present-day reality, the Commission has had to look at the pieces that make up instructional technology: television, films, overhead projectors, computers, and the other items of "hardware" and "software" (to use the convenient jargon that distinguishes machines from programs). In nearly every case, these media have entered education independently, and still operate more in isolation than in combination.
>
> The second and less familiar definition of instructional technology goes beyond any particular medium or device. In this sense, instructional technology is more than the sum of its parts. It is a systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communication, and employing a combination of human and nonhuman resources to bring about more effective instruction. The widespread acceptance and application of this broad definition belongs to the future.

Included in the report's section on "Instructional Technology Today" was a perception of this often controversial area offered by Dr. Anthony G. Oettinger, a linguist and mathematician associated with the Harvard Program on Technology and Society, in his book *Run, Computer, Run*:[95]

> My aim in analyzing the myths, the institutional failures, the brazen exploitations, the oppressive self-delusions that make a mockery of technological change in education is not to deny the promise, but to rescue it from unmerited disillusionment. I say there are no easy victories, no quick answers, no panaceas. If we are to realize the promise. we must not allow our human and material resources to be diverted into showy changes in form that will continue to block change in substance. Fundamental ignorance remains to be overcome in many realms that bear on the successful application of modern technology to education and we must therefore be prepared to encourage long-term investment in the exploration diverse paths.

It should be noted that the McMurrin Report found, "To generalize and oversimplify *the present status of instructional technology in American education is low in both quantity and quality.*"

---

[95] Educational Technology Act of 1969, p. 81.

Hearings on the Higher Education Amendments of 1970 (91st Congress)

Another series of hearings during 1970, held by the Subcommittee on Education of the Senate Committee on Labor and Public Welfare, concentrated on the provisions of S. 3474, "to amend the Higher Education Act of 1965, the National Defense Education Act of 1958, the Higher Education Facilities Act of 1963, the International Education Act of 1966, and for other purposes and related bills." [96] With Senator Claiborne Pell, the Subcommittee chairman, presiding, these three days of hearings ranged widely across the spectrum of provisions, grant programs, and services contained in the earlier legislation. On the final day, the focus shifted to the high cost of educational technology to universities. Among the witnesses:

Dr. Howard Hitchens, Executive Director, Department of Audiovisual Instruction, an affiliate of the NEA.

Dr. Rawland G. Cresser, Director of Audiovisual Services, University of Rhode Island.

After alluding to the definition of instructional technology provided in the McMurrin Commission Report, Dr. Hitchens in his formal statement quoted "one of the most prescient of our contemporaries," Dr. John W. Gardner, who had this to say about the "technological revolution in education:"

> A dozen years ago, when some of us began predicting and describing the approaching technological revolution in education, I'm afraid we gave the impression that it was approaching with supersonic speed. In fact, it has limped onto the scene. But anyone who doesn't recognize those first limping troops as the vanguard of a mighty host is just out of touch.
>
> Despite our non-system of R and D in education, which is appallingly underfinanced and ill-designed, the new technology *is* emerging. The biggest educational event of 1969 was the launching of Sesame Street—an extra-ordinarily effective children's television program. I don't want to overemphasize that one program because it represents only one aspect of the new technology—but if you haven't seen a child watching Sesame Street you've missed something.
>
> All of us in this room know by heart every twist and turn of the debate over the new technology and I don't intend to prove my grasp of it by repeating it. I'll simply say that in my opinion judicious use of video-tape, programmed instruction, computer-assisted instruction and other new approaches holds promise of a truly immense gain in the availability of the highest quality instruction—instruction that can be individualized, motivating, powerful in impact and grounded in the best of teaching practices. I'll say something even stronger. It is in my opinion the *only* hope for a radical upgrading of educational quality on a massive scale.

[96] U.S. Congress. Senate. Committee on Labor and Public Welfare. Subcommittee on Education. Higher Education Amendments of 1970. Hearings, 91st Congress, 2d session, on S. 3473 and related bills. Held Feb. 5, May 12 and 21, 1970. Washington, U.S. Govt. Print. Off., 1971. 895 p.

After pointing out that Title VI–A of the Higher Education Act of 1965 (P.L. 89–329) "provides Federal matching funds for the purchase of laboratory and audiovisual equipment, closed-circuit television equipment, and classroom materials for the improvement of instruction at the undergraduate level," Dr. Hitchens in his prepared statement noted that "students arrive on our campuses more sophisticated in their experiences with communications media than ever before." He went on to remark, in his oral testimony:

> * * * we don't want to see the impetus that has begun to support an emerging educational technology stop at this time * * * this Federal effort should be continued.

Dr. Cresser, following a description of efforts at the University of Rhode Island—including two new major classroom facilities "which are predicated on a systems approach to education—told of funding shortages and the need for continued Federal aid. He and Senator Pell subsequently discussed the value of mobile audiovisual laboratories, such as those used in Providence and East Providence, Rhode Island.

Hearings on Foreign Policy Implications of Satellite Communications (91st Congress)

Another aspect of technology's role in education was addressed during the Spring, 1970 hearings before the Subcommittee on National Security Policy and Scientific Developments of the House Committee on Foreign Affairs.[97] The three days of hearings, under the chairmanship of Representative Clement J. Zablocki, reviewed developments concerning the foreign policy implications of satellite communications, and carried forward previous Subcommittee studies of satellite broadcasting [98] and the role of developmental television in Latin America.[99]

Featured in the statement of Sig Mickelson, Vice Chairman and trustee of the International Broadcast Institute, was testimony concerned with the best way to optimally utilize satellite technology, using "the vision, the courage, and the good sense" which can result in benefits at home and abroad.

> The development of the satellite as a device for enabling men to communicate where they have never been able to communicate with speed and efficiency before opens up immense new facilities for broadly educational purposes surpassing in scope and enormity anything we have seen.

The impact of this technology upon U.S. foreign policy is manifold. One major application is for education, and Mr. Mickelson spoke of aid to developing areas (South America, India, Indonesia). The thrust

---

[97] U S Congress. House Committee on Foreign Affairs. Subcommittee on National Security Policy and Scientific Developments. Foreign Policy Implications of Satellite Communications Hearings, 91st Congress, 2d session Held Apr. 23, 28, 30. 1970. Washington, U.S. Govt. Print. Off. 1970, 212 p.

[98] U S Congress House. Committee on Foreign Affairs. Subcommittee on National Security Policy and Scientific Developments Satellite Broadcasting Implications for Foreign Policy Hearings, 91st Congress, 1st session. Washington, U.S. Govt. Print Off., 1969. 317 p Hearings held May 13, 14, 15, and 22, 1969.

[99] U S Congress. House. Committee on Foreign Affairs Subcommittee on National Security Policy and Scientific Developments Reports of the Special Study Mission to Latin America on Military Assistance Training and Developmental Television. Committee Print, 91st Congress, 1st session. Washington, U.S. Govt. Print. Off., 1970, 53 p.

of his testimony, while dealing with steps which must be taken by the U.S. leadership, also treated the need for international support:

> In order to realize the full potential of modern technology we will need intelligent and understanding support from both international and national regulatory agencies and from the public. Somehow, international arrangements are going to have to be made to manage the radio spectrum in such a way that frequencies are allocated in the most efficient manner, avoiding over-lap, giving priorities where priorities are in order, while, at the same time, furnishing maxmum service. Since the satellite signal is international, much of the regulation will have to be carried out by an international body or bodies. Granting this power to international agencies will require from participating countries some relinquishment of national sovereignty.
>
> Copyright regulations on an international basis will have to be revised so as to be more responsive to new communications technology and, in some cases, strengthened to protect artists, writers, teachers, musicians, and holders of rights to various types of informational and educational materials. Adequate protection clauses will have to be written without inhibiting free distribution.
>
> Instruments for regional cooperation will be required so that two or more countries can equitably share single communications facilities.
>
> Systems for access will have to be devised so that one country or a consortium of countries is not in a position to block the use of facilities of others, or so that a monopoly by one part of the world will not stifle the development in others.
>
> Money will be necessary, not so much to build and launch the satellites themselves. In relative terms they are inexpensive. A more costly element will be the construction of earth stations and the installation of receiving equipment, whether it be telephone, radio, telegraph, facsimile, television, or something more sophisticated.
>
> For educational purposes, the so-called software will have to be developed—the teaching materials, the philosophical approach, and the elements that go into making up a curriculum and course of study. Creating and managing the hardware will depend largely upon international arrangements; but the bulk of the software will have to be developed indigenously by those who are sensitive to the various requirements, interests, mores, and stages of development of the area in question.

Another witness, Joel Bernstein, Assistant Administrator for Technical Assistance at the Agency for International Development, noted that in developing countries "the conventional approaches to education cannot meet either the quantitative or qualitative needs of their rapidly growing and changing societies." Later, in discussing the social and political problems of Lesser Developed Countries, Mr. Bernstein reminded the Subcommittee that "some of the same problems" exist in this country. The essence of the dilemma, faced by government planners and educators alike, could be summed up in these words of the witness:

There are the problems of developing the quality of educational content, making it relevant to the actual circumstance and useful in meeting actual life needs. There are special problems of stimulating development of educational content that is well integrated with the new delivery systems. There are problems in understanding better the learning process itself and how it relates to different communication technologies in varied circumstances.

The Management of Information and Knowledge, papers prepared for the Panel on Science and Technology (91st Congress)

At the eleventh meeting of the Panel on Science and Technology with the House Committee on Science and Astronautics, held early in 1970, the chosen theme was "The Management of Information and Knowledge." [100] In the words of Chairman (Representative) George P. Miller, the three-day medley of papers and discussion focused on the "Rapid development of the computer and the revolution in communications technology . . . [and their] impact upon our society." Ten eminent educators, sociologists, and scientists contributed papers which were augmented by the creative commentary from keynote speakers and other discussants.

In his keynote address, McGeorge Bundy, President of the Ford Foundation, commenced by observing that the subject of the meeting implied "in its simple, declarative form a *problem*, a *capability*, and a *potential* if unrealized *benefit*." After pursuing this concept as regards information systems, he apprised his listeners of the limitations of this new technology:

> • its susceptibility only to data which can be quantified, and the distortions in judgment which will occur when nonquantifiable aspects are badly misjudged, or worse still, omitted entirely from the calculus;
>
> • the direct relationship between the *quality* of raw data elements or inputs and the *value* of knowledge output; and
>
> • the necessity that one's theory or explanatory hypothesis bear at least a first approximation to reality.

The moderator, Daniel Bell, Professor of Sociology at Harvard University and Chairman of the Commission on the Year 2000, sought to make another point which stressed that:

> * * * the sources of innovation in the society come from the intellectual institutions, the universities, the research institutes, the research corporations. It means moreover that the scarcest resource to the society is essentially talent (or human capital in the words of the economists) and the husbanding of human capital.

Citing a caveat penned by Harold Laski—"When the leaders of a people ask their followers to die for a dream, those followers have a right to know in whose behalf the dream is being dreamt"—speaker

[100] U S Congress House. Committee on Science and Astronautics. Management of Information and Knowledge. Committee Print (91st Congress, 1st session). 1979. 130 p A compilation of papers prepared for the meeting of the Panel on Science and Technology.

George Kozmetsky, Dean of the College of Business Administration and Graduate School of Business at the University of Texas, offered an exposition on the role of systems analysis for integrative higher education planning. In speaking of education in transition, he identified challenges to seven basic assumptions of the previous generation of educators:

(1) *Education is a privilege.*—There is increasing acceptance that education is a universal necessity that has yet to be based on meaningful standards.

(2) *Schools must group, sort, and screen students as to their ability and responsibility.*—There is increasing awareness that schools will accept, stimulate, and nurture each child to find his proper level.

(3) *Education must be separated from the real world.*—There is increasing awareness that there is a broad area of congruence between education's role as a service to society as well as the shaper of society.

(4) *Schools are the only educative force in our society.*—There is increased recognition that schools are not the only educative forces. There are other enterprises, public and private, involved in meaningful education that will be interrelated with the school systems for a lifetime of individual learning.

(5) *Education is exclusively a process by which the older generation transfers relevant knowledge to the younger generation.*—There is growing awareness that much of what the young people need to know for their generation's time today's educators have yet to learn and that there is a growing need to learn more things together.

(6) *The process of learning is essentially a formal process.*—There is a growing awareness that there is a great deal of informal learning outside the classroom. This is evident in mass media, industrial corporation training programs, and military-services training.

(7) *The teaching-learning environment is primarily batch processing involving teacher and students.*—The fear of technological devices (e.g., computers) is being gradually replaced by the growing awareness that these devices are natural extensions for the individuality of teaching as well as for the individual's development of creativity and inventiveness.

One of the dilemmas facing education today, said the Dean, was a more efficacious use of computer capabilities. He noted that oftentimes problems assigned to the computers:

> * * * can be solved by the students on today's modern electronic calculators in less than a quarter of the time spent in the modern computer labs modeling, programming, punching cards, debugging, and evaluating the quality of the results.

Regretfully, Dr. Kozmetsky noted, computer designers and educators "are equally reluctant to use the principles or techniques which they develop" and both "are reluctant to predict the future." The full text of the Kozmetsky presentation appears as Appendix 5.

A second paper which provoked rumination was that by Thomas F. Green, Director, Educational Policy Research Center at Syracuse University, entitled "Education and Schooling in Post-Industrial America: Some Directions for Policy." In his opening section, he confronted the matter of "dealing with the applications of technology *in* education and the effects of technology *upon* education:

First, it is unlikely that the application of technology within the educational system will resolve any major current problem or any problem likely to confront American education within the next fifteen years. Secondly, likely developments in technology—especially new techniques for control of behavior—may present the educational system with new problems of structure and content within the next fifteen years. These two judgments reflect a particular understanding of technological diffusion. But more important, they reflect an attempt to keep in mind the difference between what is an educational problem, on the one hand, and what is a social problem affecting education, on the other.

After considering a scenario where the costs of instructional systems decline and their quality improves along with a pressure to raise professional salaries—thus producing "a crisis of major proportions"—he warned that:

> We must focus attention not on the possible adoption of technology in education, but on the arrangements necessary if that diffusion is to take place. The application of technology within education will probably occur only when we find new methods of finance, and different ways of representing the public interest in education.

In order that the speeches and papers receive wide distribution, a special booklet, "The Management of Information and Knowledge," [101] was published separately from the complete proceedings.

Other events of note occurring on Capitol Hill during the 1969–1970 time framework included:

Passage of the National Center for Media and Materials for the Handicapped Act (P.L. 91–61) authorizing the creation of a media and materials center utilizing various technologies.

Passage of P.L. 91–230, an Act "to extend programs of assistance for elementary and secondary education, and for other purposes." This amended the Elementary and Secondary Education Act of 1965 (P.L. 88–204).

Passage of an act to establish a National Commission on Libraries and Information Science (P.L. 91–345).

Issuance by the General Subcommittee on Education of the House Committee on Education and Labor of "A Compendium of Policy Papers" on the needs of elementary and secondary education for the seventies.

Hearings to Establish a National Institute of Education (92nd Congress)

The initial effort in the 92nd Congress to explore the potential of information technology in education transpired during a series of hearings, organized and conducted during early 1971 by the Select Subcommittee on Education of the House Committee on Education and Labor.[102] Once again the leadership in this area was provided by Representative John Brademas, Chairman of the Select Subcommit-

[101] Ibid.
[102] U.S. Congress. House. Committee on Education and Labor. Select Subcommittee on Education. To Establish a National Institute of Education. Hearings, 92nd Congress, 1st session, on H.R. 33 and other related bills. Held Feb. and Mar. 1971. Washington, U.S. Govt. Print. Off., 705 p.

tee, who presided over eight days of hearings held in Washington, D.C., New York, and Chicago. Referenced legislation included H.R. 33, H.R. 3606, and other related bills dealing with the establishment of a National Institute of Education.

In considering the proposed legislation which would create a National Institute of Education (NIE), its role in undertaking and supporting research and development, including innovation in education, was examined. Furthermore, the Select Subcommittee deemed it important to review the projected National Foundation for Higher Education and any possible duplication of suggested NIE efforts. In his opening remarks, Representative Brademas noted that "the introduction of this legislation and its support by the administration represent a significant, a substantial commitment on the part of the Nixon administration to support research in education." He also mentioned that the final results of a study commissioned by the U.S. Office of Education, to be performed by Roger Levien of the RAND Corp.,[103] would soon offer recommendations concerning the structure of the institute.

Among the witnesses appearing during these sessions were:

Daniel P. Moynihan, Professor of Education and Urban Politics, Harvard University—commented upon the absence of adequate theories on the nature of human learning, and in dialogue with the congressional panel talked about examples of on-going research.

Dr. James J. Gallagher, Director, Frank Porter Graham Child Development Center, University of North Carolina—suggested the utilization of private communications resources to fulfill the need for "systematic channels of communication involving personal contact:"

> Previous limited efforts of transmitting new programs have been tried through such things as establishing demonstration centers, the design of special centers such as special educational materials network for handicapped, establishment of regional educational labs.

It was his opinion that "we have not come to grips with the issue of communication itself," and that the National Center for Educational Communication was not sufficiently funded.

Dr. Anthony G. Oettinger, Professor of Linguistics and Gordon McKay, Professor of Applied Mathematics, Harvard University—a previous contributor to congressional understanding of this often involved area. Dr. Oettinger spoke of a "major gap" between the laboratory and the consumer, and the lack of "mechanisms for translating research results into effective use, for translating the statement of a need into demand, since these are not necessarily the same thing." He continued, addressing the issues of "compatibility and property rights," and certain aspects of educational technology—books, computers, videotapes, cassettes:

> Left to its own devices, what industry has produced and is producing are the materials that are unreliable, incompatible with one another, putting an enormous burden, both financial and intellectual, on would-be users of these products.

[103] Levien, Roger E. The Emerging technology. Instructional uses of the computer in higher education. New York, McGraw Hill, 1972. 585 p.

A contributed paper of especial value was one by Kenneth Komoski, entitled "Realizing the Radical Relatedness of Technology and Education,"[104] in which he described the relationship between technology and education as a "dynamic interaction between two extremely potent forces." Two statements stand out in this treatise, which is reproduced in full as Appendix 6:

> * * * what is urgently needed (if we are ever to comprehend modern technology and its relationship to modern education) . . . undertake a fresh approach to the definition of technology built upon that which is *most basic* to all extant technologies—whether they be mechanical, electro-mechanical, electronic, biological or behavioral.
>
> * * * *Technology, it would seem, is the sum total of these activities which, in the aggregate, enable man to carry out almost any imaginable manipulation or modification of his external (material) or internal (behavioral) environments.*

Hearings on Departments of Labor and Health, Education, and Welfare and Related Agencies Appropriations for Fiscal Year 1973 (92nd Congress)

During 1972, the Subcommittee of the Senate Committee on Appropriations, chaired by Senator Warren G. Magnuson, held a series of hearings on H.R. 15417, an Act making appropriations for the Departments of Labor and Health, Education, and Welfare and related agencies, for the fiscal year ending June 30, 1973.[105] This oversight effort considered, *inter alia*, requests for the Office of Education and related agencies, special educational institutions, and the Corporation for Public Broadcasting.

Both during the prepared statement and oral testimony of Dr. Don Davies, the Deputy Commissioner for Renewal, Office of Education, the need for an increase in funding to expand the role of educational technology was stressed. Dr. Davies placed this requirement within a broader context, pointing out that:

> * * * teachers have to constantly upgrade their own skill and knowledge, and administrators and counselors . . . the heart of this educational renewal effort is to provide new skills, new knowledge, for the personnel in the schools.

Soon thereafter, Senator Norris Cotton expressed his interest in the media specialists training program under the Education Professions Development Act (P.L. 90-35), and learned that this program was integrated into the new Center for Educational Technology. A key exchange between Senator Magnuson and the witness concerning the budget request for this area reveals the scope and nature of the educational technology program:

> *Senator Magnuson. The budget estimates for National Priority Programs show a $10,000,000 increase for Educational Technology Demonstrations (from $20 million in fiscal year*

---

[104] To Establish a National Institute of Education, pp 346–352

[105] U.S. Congress, Senate. Committee on Appropriations Subcommittee of the Committee Departments of Labor, Health, Education, and Welfare and Related Agencies Appropriations for Fiscal Year 1973. Hearings, 92d Congress, 2d session, held 1972. Part 1, 1302 p

1972 to $30 million in fiscal year 1973). This new $10,000,000 appears to be all going to a new program—special technology projects. (p. 111). What is envisioned here? What kind of projects would be funded with this $10,000,000?

Dr. Davies. The $30 million request for educational technology will support two existing programs at the 1972 levels, educational broadcasting facilities $13 million and Children's Television Workshop—$7 million. The increase of $10 million is entirely for a new program of educational technology demonstrations. Of this amount $5.4 million will support the Rocky Mountain and Appalachian satellite demonstration projects. $1.5 will provide support for the operational development of a bilingual children's television project and $1 million will continue a few projects started in fiscal year 1971 and 1972. The remaining $2.1 million will be used for such projects as computer assisted instruction, cable television, and training teachers to use new technology projects.

Senator Magnuson. What is the statutory authorization for this program for fiscal year 1973?

Dr. Davies. The Cooperative Research Act, as amended, which provides specific authority for demonstrations in education provides legislative authority for these projects. Under the Senate passed version of the Higher Education Act, this authorization would be changed to the General Education Provisions Act.

Later in the oversight hearings,[106] the production and use of audiovisual hardware and software were discussed, since, in the words of James Parton—President of the Encyclopaedia Britannica Educational Corporation—"there is an insatiable interest at every school and college in increasing use of audiovisual materials."

Another key witness was Dr Howard Hitchens, Executive Director of the Association for Educational Communications and Technology, an affiliate of the National Educational Association. After underscoring the 1970 Commission on Instructional Technology's definition of this field—"a systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communications, and employing a combination of human and non-human resources to bring about more effective instruction"—he cited several examples of how NDEA III support has been used:

Norfolk, Va.—extensive utilization of audiovisual equipment and materials at Camp Allen Elementary, an "open school," for reading programs involving 930 students.

St. Joseph, Mo.—cassette recorders and multi-media reading programs for remedial work in reading and English, affecting at least 8,500 students.

Texas—taped television news reports of President Nixon's trip to China were played on NDEA-furnished equipment for disadvantaged students who did not have television at home.

---

[106] Ibid., Part 7, p 6538–6577

Hearings on Educational Technology (92d Congress)

The Select Subcommittee on Education of the House Committee on Education and Labor, under the chairmanship of Representative John Brademas, moved once again to consider the processes of technology in the educational realm through hearings convened in May, 1971 and September, 1972.[107] Serving as a legislative point-of-reference was H.R. 4916, a bill "to improve educational quality through the effective utilization of educational technology."

Citing the complexities of employing such technology, Representative Brademas observed that:

> * * * technology is more than machines. Projectors, monitors, tape recorders and computers; cable systems, microwave nets, dial access systems and cassette systems—these are all the result of creative engineering. But technology is more than these. Technology is all forms of applied knowledge, and thus it includes routines, techniques; and of course the content or software transmitted through these new mechanical and electronic devices is itself technology or applied knowledge.

Then he spoke of the difficulties in ensuring the use of educational technology, as was experienced after the National Defense Education Act (P.L. 85–865), Title III, had provided for projectors, video recorders, and costly language laboratories which ended up unused, and "ignored by teacher, student, and administrator alike." The linkage with key legislation calling for the establishment of a National Institute of Education (H.R. 33, et al.) which would serve as a "focal point in the Federal Government for the support and stimulation of research and development in education" also was noted.

Inasmuch as there were repeated allusions to H.R. 4916, its statement of purpose deserves exposition:

STATEMENT OF PURPOSE

> SEC. 101. The purpose of this title is to improve the quality of preschool and elementary and secondary education through the effective utilization of educational technology by (1) encouraging significant applications of existing technology to preschool programs and in elementary and secondary education, (2) the development and demonstration of technological innovations in education, (3) the expansion of the current general application of appropriate technologies and materials for instruction and learning, (4) strengthening the capabilities of teaching, administrative, and ancillary staff in schools, (5) research into educational technology, including statistical and information services, and (6) strengthening the leadership resources of State educational agencies in educational technology.

Among its provisions were those establishing a Bureau of Educational Technology, a National Advisory Council on Educational Technology, and State Advisory Councils on Educational Technology.

---

[107] U S. Congress. House. Committee on Education and Labor. Select Subcommittee on Education. Educational Technology. Hearings, 92d Congress, 2d session, on H.R. 4916. held May 5 and Sept. 13, 1972. Washington, U.S. Govt. Print. Off., 1972. 368 p.

Serving as a primary reference for the Select Committee at this time was the report by The Carnegie Commission on Higher Education, *The Fourth Revolution: Instructional Technology in Higher Education*. Released in mid-1972, this set of recommendations reflected a determination to emphasize the role of technology in instruction both in the formal teaching-learning situation and when general information is obtained as the result of "informal exposure to information and ideas." The "Contents" of this report, along with selected sections—"Major Themes and Marginal Observations" and "Reasonable Goals for Instructional Technology"—are found in Appendix 7.

An interesting figure appeared in The Carnegie Commission study, which projects the use of electronic technology ahead to the year 2010:[108]

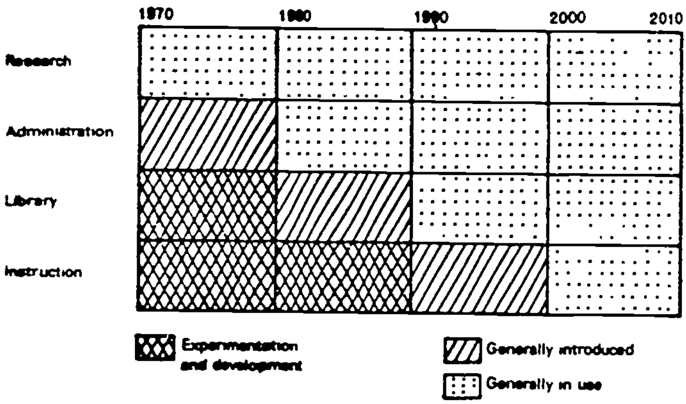


FIGURE 6.—Projected use of electronic technology to the year 2000.

Source. Staff of The Carnegie Commission on Higher Education

Also treated were significant developments in other nations, specifically:

- Sweden's Television-Radio University
- Japan's University of the Air
- Great Britain's Open University
- West Germany's extramural studies on the air

Another area of emphasis in this study, featured in the section on "The Penetration of the New Technology," was a look at how extensively the various media are used for instruction. Reference was made to a preliminary report on a study by Jarrod W. Wilcox of the MIT Alfred P. Sloan School of Management, in which he defined nine technologies:[109]

---

108 The Fourth Revolution Instructional Technology in Higher Education. New York, McGraw-Hill, 1972, p 2 A report commissioned by The Carnegie Commission on Higher Education.

109 Wilcox, Jarrod A Survey Forecast of New Technology in Universities and Colleges Cambridge, Mass., Massachusetts Institute of Technology, 1972. (Working paper.)

Routine audiovisual techniques The classroom use of films, taped lectures shown on closed-circuit television or in listening laboratories, etc.

Programmed instructions The student uses a test or simple supplementary device which employs step-by-step feedback reinforcement techniques to progress through sequentially ordered, structured material. Examples are programmed texts and self-study language audiotapes.

Routine computer-assisted instruction The computer is used in the instructional process for either computerized programmed instruction or for drill and practice exercises.

Computer simulation The computer is used in exercises involving student investigation of the properties of a "pseudo-reality" generated by a model of the phenomenon under study.

Advanced computer-assisted instruction The computer is used in a flexible, individualized way to support student exploration of a well-defined body of knowledge; this may include Socratic dialogue, tutorial exercises, and the ability to answer at least some unforeseen student questions.

Computer-managed instruction Measures of the student's performance are monitored and analyzed by the computer; based on this the computer provides aid or direction to the student or teacher as to the most suitable packet of instructional material, such as film, programmed instruction, or live teacher, to be used next.

Remote classroom broadcasting and response The use of remote television broadcasting from a central location to dispersed classrooms, with at least audio-live response or questions from the students.

Student-initiated access to audiovisual recordings The use of audiovisual recordings in a technological environment sufficiently inexpensive and easy to use to allow individual student-initiated access to recorded lectures or demonstration material.

Computer-aided course design The use of computers to record and analyze student responses to instructional packets in computer-assisted and computer-managed instruction in order to provide information for the design of improvements in the instructional material.

One facet of the MIT study involved having 90 technologists who had participated in various national conferences on educational technology and 152 faculty members "representing a broad national cross section of views" predict when these nine basic technologies would be in "routine use." Figure 7 contains this matrix of projections: [110]

Mention was made in The Carnegie Commission report that in 1968 Congress had enacted a series of amendments to the Higher Education Facilities Act of 1963 (P.L. 88–204), which included legislation creating a "Networks for Knowledge:"

> • * * * a plan to encourage colleges and universities to share, through cooperative arrangements, their technical and other educational and administrative facilities and resources.

[110] Instructional Technology in Higher Education, p. 39.

FIGURE 7

MATRIX OF PREDICTED USE OF 9 BASIC TECHNOLOGIES

[Faculty mean predictions of availability and routine undergraduate and graduate use, and technologists' mean predictions of routine use of nine basic technologies]

	Faculty predictions of availability	Technologists predictions of routine use	Faculty predictions of routine use for undergraduates	Faculty predictions of routine use for graduates
Routine audiovisual technology	1972	1974	1975	1989
Programed instruction	1975	1976	1982	2010
Routine computer-assisted instruction	1977	1979	1982	1992
Computer simulation	1979	1979	1983	1985
Advanced computer-assisted instruction	1984	1989	1992	1996
Computer-managed instruction	1986	1983	1995	2005
Remote classroom feedback	1974	1979	1984	1996
Student-initiated access to audiovisual	1975	1979	1979	1986
Computer-aided course design	1993	1983	1992	2003

Source: Wilcox, 1972.

Included in this wide-ranging mandate would be:

- joint uses of classrooms, libraries, laboratories, books, materials, or equipment;
- access to specialized library collections through interinstitutional catalogs and suitable media for electronic or other rapid transmission facilities; and
- establishment and joint operation of electronic computer networks and programs.

Funds for this authorization were never appropriated.

A topic often alluded to throughout the various hearings and studies of the 1970 decade received special treatment in "The Fourth Revolution:" the impact on faculty of the new technology. Four "new roles" were described: the teacher, the instructional technologist, the media technologist, and the information specialist. These professionals, along with teaching assistants, were seen as fulfilling the key assignments related to the integration of diverse technologies into the instructional milieu.

Various witnesses, during the course of both hearings, gave briefings, and slide and film presentations on the contributions to education of audiovisual aids, videodiscs, cartridge TV, and other videotape systems.

At the outset of the second hearing (in 1972), Representative Orval Hansen summarized the two simultaneous problems which the United States faces in education even today:

> One, how to make the educational dollar more productive; and, two, how to provide high quality education in every school. To solve these we need to investigate every promising development in educational technology.

His bill, H.R. 16572, would establish a Council on Educational Technology in the Department of Health, Education, and Welfare which would be empowered to:

(1) develop precise descriptions of educators' needs with regard to educational technology;

(2) assess the quantity and quality of use of various types of technology in educational settings, including educational consumer reactions and evaluation of this technology;

(3) encourage and support the testing and assessment of technological equipment being marketed for educational purposes and the publication and dissemination of test results;

(4) encourage and support the development of prototype models of technological equipment designed to meet specific educational needs when these needs are not met by existing technological equipment on the market and encourage the use of free license arrangements to stimulate more widespread availability of common format equipment;

(5) where indicated after thorough study, develop specifications for common formats to assure compatibility, reliability, and durability for various types of technological equipment for educational use, and continually review these specifications based on assessment of the use and effectiveness of the equipment. Where deemed necessary, adherence to the specifications may be made a condition of the expenditure of Federal funds for education-use equipment.

(6) make an annual report to the Congress and such other reports as it deems appropriate, on its findings, recommendations, and activities with respect to sections 2 and 3 including, as appropriate, an assessment of the creation of high quality program materials, evaluation of the supply and demand of specialized personnel for the design and implementation of effective media-based instructional materials, and other specialized concerns, which, in the opinion of the Council, are of importance to the effective development of an improved and expanded learning system.

(7) consult with such Federal and non-Federal advisory councils, committees, and professional associations, as may have information and competence to assist the Council. All Federal agencies are directed to cooperate with the Council in assisting it in carrying out its functions.

Studies relevant to this area which were included or mentioned in The Carnegie Commission Report:

"Reappraisal of the Education Technology Industry," proceedings of a conference held November 16–18, 1969 at the Center for Continuing Education, University of Chicago.

The Emerging Technology, by Roger E. Levien of the RAND Corporation, to be published by McGraw-Hill in 1972 as part of The Carnegie Commission on Higher Education series.

"Will Information Technologies Help Learning?" by Anthony G. Oettinger with Nikki Zapol, to be published in a Carnegie Commission volume in 1972 on the undergraduate curriculum.

The pace of legislative exploration quickened perceptibly in the 1971–1972 period, as the record indicates. In addition to the aforementioned major activities, there were other achievements meriting attention:

Passage of the Emergency School Aid Act (P.L. 92–318, Title VII), which authorized the development and use of ne curricula and instructional methods, including the acquisition of any instructional materials and technologies, for use by all children regardless of race, color, or economic standing.

Passage of the Rural Development Act of 1972 (P.L. 92-419, Title V), with a multiple purpose:

(a) to provide multistate regional agencies, States, counties, cities, multicounty planning and development of districts, businesses, industries, organizations, Indian tribes on Federal and State reservations or other federally recognized Indian tribal groups, and others involved with public services and investments in rural areas or that provide or may provide employment in these areas the best available scientific, technical, economic, organizational, environmental, and management information and knowledge useful to them, and to assist and encourage them in the interpretation and application of this information to practical problems and needs in rural development;

(b) to provide research and investigations in all fields that have as their purpose the development of useful knowledge and information to assist those planning, carrying out, managing, or investing in facilities, services, businesses, or other enterprises, public and private, that may contribute to rural development;

(c) to enhance the capabilities of colleges and universities to perform the vital public service roles of research, transfer, and practical application of knowledge in support of rural development;

(d) to expand research on innovative approaches to small farm management and technology and extend training and technical assistance to small farmers so that they may fully utilize the best available knowledge on sound economic approaches to small farm operations.

Issuance by the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics of the committee print containing selected references on "New Technology in Education," which was prepared in 1971 by the Education and Public Welfare Division of the Congressional Research Service, Library of Congress.

Hearings on Education for the Handicapped, 1973 (93rd Congress)

Early in 1973, hearings were held by the Subcommittee on Handicapped of the Senate Committee on Labor and Public Welfare.[111] Senator Jennings Randolph, the Subcommittee chairman, presided over the three days of hearings which focused on a series of bills concerned with aid to handicapped citizens:

S. 896, the Education of the Handicapped Amendments of 1973
S. 6, the Education for All Handicapped Children Act
S. 34, the Autistic Children Research Act
S. 808, the Screening for Learning Disabilities Act

[111] U.S. Congress. Senate Committee on Labor and Public Welfare. Subcommittee on Handicapped. Education for the Handicapped, 1973. Hearings. 93rd Congress, 1st session, held Mar. 20, 21, 23, on S. 896. Washington, U.S. Govt. Print. Off., 1973. 694 p.

Among those testifying to the criticality of this area was Dr. John Belland, Director of the National Center on Media and Materials at The Ohio State University, who identified several initiatives taken by this new organization:

> * * * providing technical assistance to various projects and programs funded by the Bureau of Education for the Handicapped.
>
> * * * begun discussions with two research and development projects funded by the Bureau of Education for the Handicapped to help them with media production tasks.
>
> * * * working to develop an efficient, straightforward system for moving products produced under Government funding into commercial distribution, working very closely with HEW, publishers alert.
>
> * * * beginning work on facilitating the processing of data-gathering forms clearance as required by the Office of Management and Budget, so that data can be gathered effectively as we attempt to assess the instructional materials needs of handicapped learners and field test instructional materials to insure their validity and effectiveness.
>
> * * * assumption of the leadership stance mandated by Public Law 91-230 [Amendments to the Elementary and Secondary Education Act of 1965] . . . [and] have begun an important project of determining the educational technology needs of handicapped learners, their teachers, and parents.
>
> * * * leading a consortium of special education instructional materials centers and regional media centers for deaf personnel in designing an overall strategy for materials development and in setting priorities on the development of these materials. This includes setting standards and establishing procedures acceptable for the field testing of products.
>
> * * * coordinating and synthesizing the activities leading toward the development of the national information system for instructional materials and a national delivery system for instructional materials.

Dr. Belland then urged "long term Federal support" since the market for developers of materials for the handicapped is not large. The overall strategy of a coordinated effort in this field was reflected in these words:

> In summary, it is important that the National Center on Educational Media and Materials for the Handicapped, the Special Education Instructional Materials Centers, the Regional Media Centers for the Deaf, and the Regional Resource Centers work together to facilitate the development of an appropriately designed instructional program for every handicapped child. Educational technology seems to provide a vehicle for this design effort; yet the level of sophistication that has been achieved in educational technology for general education only scratches the surface of the problems of the precision design required for each handicapped learner. The

field is presently using materials designed for the ordinary learner, with some relatively crude adaptations by the teacher. It is also trying to employ materials which have had no systematic field test on the general population, much less on the population of concern. Thus, the state of the art of educational technology needs advancing as it makes a concerted effort to deliver appropriate instructional materials for the handicapped learner.

The commentary of Dr. Edward Palmer, Research Director for the Children's TV Workshop, led the Subcommittee to another facet of the topic:

> We felt, and continue to feel, that the learning process for handicapped children and normal children is essentially the same, and that the same learning principles apply to both handicapped and normal children. Our television programs, "Sesame Street" and "The Electric Company", have been designed to take advantage of what psychologists have learned about education and instruction. The intellectual process is important when you are dealing with normal children, but is especially so when you are dealing with handicapped children.
>
> * * * many handicapped children who are homebound or who live a good part of their lives in wards and in special institutions and are oftentimes inactive not by choice, but by circumstances of birth, have an opportunity to find on the television screen materials to help them learn concepts that are important to their development, to their later schooling, and we are encouraged that we have had an opportunity through the development of "Sesame Street" and "The Electric Company" to make a contribution to the learning and the welfare and perhaps the delight and occasional joy of these children.

And in a philosophical and perhaps prescient vein, the witness quoted E. B. White who had said that:

> I believe television is going to be the test of the modern world, and that in this new opportunity to see beyond the range of our vision, we shall discover either a new or unbearable disturbance of the general peace or a saving radiance in the sky. We will stand or fall by television, and of that I am quite sure.

Dr. Patrick Suppes, Director of the Institute for Mathematical Studies in the Social Studies at Stanford University, commenced his oral testimony by describing a multi-year program conducted under the sponsorship of the Bureau of the Handicapped; its focus was the application of CAI techniques for deaf students:

> The students use teletypes, they look like a teletype or typewriter to the student, of course, and these are connected by telephone lines to our central computer at Stanford. We have been bringing elementary mathematics and language arts to elementary school students in California, Texas, Oklahoma,

Florida, and here on the Gallaudet College campus in Washington. These connections are made by long-line telephone connections to the various schools. I think there are several things to remark on.

One is that in the case of deaf children especially there is a problem of giving those young students an appropriate and adequate amount of continual interactive communication. One of the main deficits of deaf children is the absence of the kind of continual communication by means of language that ordinary students have. One of the things one can do with interactive computer terminals is to give them the opportunity to increase their interaction and at the same time to develop their basic skills. I should emphasize that our work has been concerned with basic academic skills, so when we talk about jobs, vocational training, later careers for handicapped youngsters—the first task is to bring them up to some reasonable level in basic academic skills, reading, writing and arithmetic in the classical terms or as we put it today, mathematics, reading and language arts.

Following a dialogue about the actual student functioning at a special keyboard involving Senator Harrison A. Williams and Dr. Suppes, attention was then turned to the experience of Dr. Kenneth Cross, Research Coordinator for the Research and Development Complex, State University College in Buffalo. He explained that the college is a part of the National Special Education Instructional Materials Center Network, and is also concerned with the National Media Center:

Our major contribution as a center has been the development of computer based resource units. These resource units are very different from the kind of computer application Dr. Suppes was describing, in that the student does not sit at a terminal and interact with a computer; rather in our operation, the teacher and student select learning objectives, and enter our system to find out what instructional materials and instructional activities will best help to meet the objectives of the teacher and student.

Our system is based on the notion that every learner, whether he is an individual with special learning problems or not, has in essence a need for individualized training or, almost literally, specialized education. Typically we ask a teacher to select five learning objectives for a class as a whole and two learning objectives for each student within the class, and then we try to provide the teacher with a wide range of activities and materials that are appropriate to the child's chronological age, mental age, learning handicaps, if he has any, interests, and learning level.

He then offered an insight into the ways in which the computer based resource units had been utilized thus far, the involvement of agencies below the Federal level, and the benefits to teachers and students alike:

The Network established a communications and training link to teachers, and made it possible to stimulate the concept on a widespread basis. Once the potential of the units had been demonstrated through the Network, a considerable number of State and local agencies became interested in supporting the concept.

State support accomplished the computerization of the entire New York State drug and health program, as well as curriculum guides in a wide variety of other target areas: Science, mathematics, environmental education, career education. In short, the investment made at the Federal level was far exceeded by the contributions of the State and local levels.

Some of the research related to computer based resource units is most favorable both in terms of improving teacher skill and learning. Experimental research indicates that teachers using these units become much more sensitive to the needs and abilities of their students and tended to modify their programs and procedures accordingly.

* * * computer based resource units represent only one of a wide variety of information centers that we see as essential. Dr. Suppes' system for working with students directly is very necessary. Other systems, too, those for instance which provide research or access to research abstracts, those providing information about where specific materials can be found so they can be put into use, and those providing information about the comparative values of one method of material over others are just a few of the kinds of information that are needed.

Most of the components for a total information system already exist in one form or another, and the job ahead seems to be to amalgamate these into an overall system.

It should be noted that the full text of a major study in this area was made part of the hearings documentation: "Computer-Assisted Instruction for Dispersed Populations: System Cost Models" by John Ball and Dean Jamison of the Stanford University faculty.[112]

Other events of note during the 1973–1974 period, involving the Congress:

Passage of the Education Amendments of 1974 (P.L. 93-380), which included the provisions that "(1) the Commissioner of the Office of Education is empowered to use, at his discretion, certain funds for educational television; and (2) the Office of Library and Learning Resources is created to administer all funding and oversight of those technologies used for instructional purposes."

Passage of the White House Conference on Library and Information Services Act (P.L. 93-568), which included phraseology that "new achievements in technology offer a potential for enabling libraries and information centers [including educational institutions] to serve the public more fully, expeditiously, and economically."

Demonstration of the PLATO system during the hearings on Federal information systems, plans, and the development of advanced

[112] Education for the Handicapped. 1973. p. 379–436.

information technologies held by the Subcommittee on Foreign Operations and Government Information of the House Committee on Government Operations (1973).

Hearings on the Telecommunications Facilities and Demonstration Act of 1975 (94th Congress)

In the first session of the 94th Congress, two days of hearings were held by the Subcommittee on Communications of the House Committee on Interstate and Foreign Commerce.[113] Under the chairmanship of Representative Torbert H. MacDonald, the legislative focal point was H.R. 4565, a bill to "extend the educational broadcasting facilities program and to provide authority for the support of demonstrations in telecommunications technologies, and for other purposes."

The purpose of this legislation was stressed by Representative MacDonald in his introductory remarks:

> This legislation has been submitted by the administration to extend the educational broadcast facilities program and to provide new authority for the support of demonstration projects in telecommunications for the distribution of health, education, and social service information.

An amplification of this statement was set forth in a letter from Caspar H. Weinberger, Secretary for DHEW, to Carl Albert, Speaker of the U.S. House of Representatives, which said in part:[114]

> This bill has two basic purposes. First. the Department's direct support for over-the-air educational radio and television broadcasting facilities would be extended for a five-year period Television broadcast coverage of these stations now extends to almost 78 percent of the population, while radio coverage is approximately 65 percent; extension of the facilities program for this additional period would permit the Department of Health. Education, and Welfare essentially to satisfy the original goals of the program while phasing down its direct support for construction of broadcasting facilities. Moreover, because the number of public television stations in the country represents a nearly complete and mature system, and because increased broadcast coverage is achievable only at unacceptably high per-viewer costs as the 100 percent coverage level is approached, the funding criteria for the broadcasting facilities program would be amended to emphasize (1) the strengthening of the capability of existing facilities, (2) adapting existing facilities to additional educational uses, and (3) extending educational broadcasting services, with due consideration to equitable coverage of all areas of the country.
>
> Secondly, the legislation would provide authority for a telecommunications program designed to demonstrate ways to meet the common needs of the health and education community.

---

[113] U.S. Congress. House. Committee on Interstate and Foreign Commerce. Subcommittee on Communications. Telecommunications Facilities and Demonstration Act of 1975 Hearings. 94th Congress. 1st session, held June 4, 1975 on H R. 4564. Washington. U.S. Govt. Print. Off., 1975. 145 p.

[114] Ibid p 4

> This legislation would provide a single broad authority in the Office of the Secretary to create the multi-user telecommunications services and facilities which will make it possible for health, education, and social service providers jointly to develop more efficient and economical means of meeting the nation's needs.

A five-year facilities program was outlined for the Subcommittee by Hartford N. Gunn, Jr., President, Public Broadcasting Service, which would "provide the delivery capabilities public television must have to fill the mandates laid down in the 1967 act" (P.L. 90-129):

> The first element of the program is to reach in fact with a dependable signal the 80 percent of the population that our 254 existing stations reach in theory.
>
> The second element in the program . . . is to create a system in which there are genuine local service options so that each station can use national resources according to its own priorities and it can also produce programs to meet the special needs of that community.
>
> The third element of the program is establishment of new stations wherever there is a population to support them to reach an additional 10 percent of the population.

In his prepared statement, Mr. Gunn elaborated upon the unserved 10 percent, saying that "new technologies may be the link" to fulfilling that third program objective.

Typical of the possible demonstrations in using telecommunications technology is one described by Dr. Gordon A. Law, Director, Satellite Technology Demonstration for the Federation of Rocky Mountain States. He told of the Federation's management and operation of a demonstration utilizing NASA application technology satellite-6, as well as ATS-3 and ATS-1, for the purpose of improving "the delivery of public services to the people of the Rocky Mountain States." A more complete account of this Satellite Technology Demonstration (STD) appears in Appendix 8.

As a result of these hearings, and related congressional action, the Educational Broadcasting Facilities and Telecommunications Demonstation Act of 1976 (P.L. 94-309) came into existence.

Other measures passed by the Congress during 1975 and 1976 which concerned the role of technology in education included:

Passage of the Education for All Handicapped Children Act of 1975 (P.L. 94-142), featuring a provision "for the establishment and operation of centers on educational media and materials for the handicapped, which together will provide a comprehensive program of activities to facilitate the use of new educational technology in education programs for handicapped persons."

Passage of the Education Amendments of 1976 (P.L. 94-482) which included sections dealing with "teacher centers" which may:

> (A) develop and produce curricula designed to meet the educational needs of the persons in the community, area, or State being served, including the use of educational research findings or new or improved methods, practices, and techniques in the development of such curricula; and

(B) provide training to improve the skills of teachers to enable such teachers to meet better the special educational needs of persons such teachers serve, and to familiarize such teachers with developments in curriculum development and educational research, including the manner in which the research can be used to improve their teaching skills.

The overall purpose of this measure was to extend the Higher Education Act of 1965 (P.L. 89-329) and the Vocational Education Act of 1963 (P.L. 88-210).

Hearing on Rural Telecommunications (95th Congress)

The Subcommittee on Communications of the Senate Committee on Commerce, Science, and Transportation convened a one-day hearing in 1977 to consider various aspects of rural telecommunications.[115] In particular, the Subcommittee sought to examine potential applications of telecommunications technology, including cable TV and broadband communications, for ameliorating or solving rural communication and public service delivery needs. Senator Ernest F. Hollings, the Subcommittee chairman, observed in opening the session that "the problems of rural America often are unique and just as often have been overlooked . . . [and] that these rural areas frequency are not provided basic services that those of us living in urban areas take for granted." He then noted that many recommendations had been forthcoming about "substituting communications for transportation in the delivery of public services (including health, education, law enforcement)," as well as various commercial uses such as security systems and pay TV.

A recent study by the Office of Technology Assessment on communications and rural America[116] was cited by the Chairman, who explained that its purpose was "to determine the feasibility and value of experimental efforts to develop public service for rural areas through the use of broadband communications techniques."

The first witness, William Urban, Superintendent of Blair High School (Blair, Wisconsin), described the migration of people into rural Wisconsin; these included:

> * * * people who are retiring early and are coming back. In other words, they are looking for a second occupation.
>
> * * * the back to Mother Nature movement. Young couples coming in who have lived in the city all their life and all of a sudden want to live off the land.
>
> * * * people who leave the rural areas and their children are starting to grow up and they realize they do not want them to stay in a large metropolitan area.

He then told of the Western Wisconsin Communications Cooperative and its two goals: "to bring broadband communications into Trempealeau County and to utilize it by interconnecting the eight schools by a two-way system." The sponsors sought Federal support under

[115] U.S. Congress. Senate. Committee on Commerce, Science, and Transportation. Subcommittee on Communications. Rural Telecommunications. Hearings, 95th Congress, 1st session, held Apr. 6, 1977 on Oversight of Rural Telecommunications. Washington, U.S. Govt. Print. Off., 1977. 138 p.

[116] U.S. Congress. Senate. Committee on Commerce, Science, and Transportation. Communications and Rural America. Committee Print, 95th Congress, 1st session. Washington, U.S. Govt. Print. Off., 1977. 49 p.

the Vocational Education Act of 1968 (P.L. 90–576) and the Rural Development Act of 1972 (P.L. 92–419). The witness told of many obstacles to receiving aid for demonstration projects, saying that a "tremendous amount of time and effort [were] lost." In written information subsequently submitted by Mr. Urban for inclusion in the hearings record, he enumerated contributions that cable TV does make or can make on the teaching and learning process. All are predicated on the fact that teaching and learning are essentially dependent upon effective communications:" [117]

(1) The sharing of resources among libraries, transmission of print resources via slow-scan and facsimile, recorded readings for the homebound or blind.

(2) Providing a vehicle for conveying to learning stations—if desired to many learning stations simultaneously—timely learning experiences in a variety of formats. These include messages offered verbally, on sound film, videotape, colored slides, and similar media. The effectiveness of a multi-sensory approach to learning has been well-established.

(3) Providing for schools both a "delivery system" and a retrieval system for interviews with government officials, city administrators, visiting artists and other noteworthy resource people with possibilities for instant "live" transmission of their ideas or delayed delivery of their taped remarks. To this is added the capacity for student reaction with the person appearing before the camera requiring a sufficient reservation of channels.

(4) The availability of CATV studies for school use provides opportunities for exhibiting and sharing performances in music, drama, forensics, and other school-based activities, not only with fellow students but also with school patrons, the adult public. Added motivation, the learning of production techniques, and "pride in accomplishment" are among the significant benefits.

(5) Televised programs which may be captured on videotape and held for the instructionally opportune moment, CATV connections offer the "flexibility" and "repeat" advantages so frequently needed in school situations.

(6) An increase in communication skills to provide better understanding of the mass media, aid to slow learners, stimulation for reading, and improvement of self-image are other potential benefits of televised instruction.

(7) Experiences with CATV facilities which will offer participating students certain options for career-direction in a predictably vigorous field of work.

(8) Serving as a coordinating influence between school and home, delivering important information regarding career-guidance, school administration and regulations, health and safety practices, and curriculum changes.

(9) Availability of interconnections between schools, universities, technical institutions, art galleries, and other educa-

[117] Rural Telecommunications, 1977 p 18

tional environments to provide for sharing of talent and learning experience. Cost effectiveness advantages are obvious.

(10) Serving as the principal vehicle (given two-way facilities) for the "Open University" concept of continuing education.

(11) Expediting communications as increased demands on education require a larger variety of services making improved administrative communication imperative. Memos and meetings often result in serious delays in carrying out local programs.

(12) Providing instruction for homebound or hospitalized students, service to computer terminals at school or at home, school data transmission, opportunities for professional growth of staff—all are possibilities for CATV-assisted education.

In other prepared testimony, offered by Dr. William J. Thaler, Acting Director, Office of Telecommunications Policy (Executive Office of the President), reference was made to the OTA report, "The Feasibility and Value of Broadband Communications in Rural Areas,"[118] and a subsequent conference (November 1976) concerning the potential of telecommunications in rural America. Dr. Thaler continued:

> The gap in availability of medical, educational, and local government services between urban and rural America is well recognized, and the possibilities of using telecommunications to upgrade rural social services have also been noted. There have been many such services conceptualized, and many have been tried in the fields of telemedicine, education (using audio or video feedback) and local government administration. Nevertheless there is no comprehensive body of knowledge on costs, acceptability of the service, improvement over conventional methods, or importance of the particular demographic setting on these variables. I submit, Mr. Chairman, that one of the most important considerations at the start should be to assure that any rural demonstration program we may contemplate makes a positive contribution to the store of knowledge on these matters.

Another commentary, presented in person before the Subcommittee by Dr. Alfred J. Eggers, Jr., Assistant Director for Research Application at the National Science Foundation, dealt with NSF support for "applied social science research on nonentertainment applications of telecommunications technology," such as projects in Spartanburg, S.C. and Reading, Pa. He noted that certain lessons had been learned by NSF as a result of these and related experiences:

> 1. Engineering solutions can be achieved for almost any communications technology.
>
> 2. Problems of organizing and aggregating diverse service agencies and service deliverers are critical to the success of demonstration.

[118] U.S. Congress, Office of Technology Assessment. The Feasibility and Value of Broadband Communications in Rural Areas. Washington (Office of Technology Assessment), 1976, various pagings.

Finally, in developing and implementing demonstration projects, very careful attention to matching actual service needs to possible technical solutions is well worth the investment of resources.

Further insight into the Spartanburg project was provided by Dr. Bill Lucas, Senior Social Scientist for the RAND Corporation, who had served as RAND's coordinator for the two-way cable project:

In Spartanburg we have used two-way video to offer inservice training in day-care centers. We have interconnected senior citizen centers to create programs to meet the particular needs of the elderly. Simple data terminals in the home have been used by parents to take courses in early childhood development in order to better take care of their children. Adults have used a home terminal to take a cable education course to prepare to take a state examination that certifies them as having a high school education.

In every case, the participants have been satisfied with the quality of the services. People have voted with their feet and, by staying through the programs, have shown the adequacy of being able to offer service over two-way cable. These services, by and large, can be generalized to other technologies.

A more detailed description of the Spartanburg project has been selected for inclusion as Appendix 9.

Hearings on Computers and the Learning Society (95th Congress)

The most extensive hearings held in either house of Congress concerning the multifaceted impact of information technology on the field of education took place during 1977 at the instigation of the Subcommittee on Domestic and International Scientific Planning, Analysis and Cooperation of the House Committee on Science and Technology.[119] Representative James H. Scheuer, the Subcommittee chairman, managed the six days of hearings. In his formal statement upon opening the hearings, he explained both the motivation for and pattern of this series of sessions:

The United States is a nation which has been characteristically noted for its reliance and faith in technological solutions to some of the world's most complex problems. Thus, a growing cadre of persons has developed who believe that technology could, once again, somehow be used to address the perplexing problem of declining student performance. The sentiment runs: If we can put men on the moon, why can't technology be used to help Johnny learn to read and write?

* * * * *

The pattern of inquiry followed in this study of "Computers and The Learning Society" has two basic themes. First, we will look at past promises and achievements in the field to see what has been needed and what has been delivered. Then, we will discuss what developments in the area of computer technology may lie ahead, how these developments might be

[119] Computers and the Learning Society.

useful in the quest for better means for educating the public, and how the Federal Government might aid in the application of computers to the field of education. In other words, the purpose of this inquiry will be to discern realistic solutions based on a critical assessment of our past successes and failures in this area.

Very briefly, the format of this oversight review will be as follows:

Today, the testimony will focus on an examination of the successful application of Computer-Managed Instruction in a school district. It appears as if, in this particular district, a thorough analysis of project goals and the utilization of an appropriate level of computer technology have resulted in the effective implementation of a computerized instructional support system.

On October 5, the review will focus on three major computer-assisted instructional systems that have been developed over the past fifteen years and that are currently being commercially marketed. On October 12, testimony will be concerned with the findings and direction of current research and development efforts, and on October 13, various Federal agencies will comment on and respond to the issues covered during the previous three days. On the final day of this oversight review—October 18—the role of computers in aiding the education of the handicapped will be examined.

Yet another day of hearings (October 27) was held in order to obtain all of the testimony desired by the Subcommittee.

The first witness to discuss the application of Computer-Managed Instruction (CMI) in a school district was Dr. Gerald L. Freeborne, Assistant Commissioner for Program Analysis and Evaluation from the New York State Education Department, who laid the groundwork for the Subcommittee's consideration of this topic:

C.I.M.S., which is the acronym for the Comprehensive Instructional Management System. has some unique characteristics which I believe are important, and which go beyond the computer aspect.

First of all, teachers in the district, in a cooperative working relationship, developed instructional objectives for the entire district which are being used in district 18 by all the teachers.

The second component of the system involves having teachers develop suggested learning activities that can be used by all the teachers in the district.

Another element is the comprehensive testing program which links in with the instructional objectives. As a result of having this information on a computer which maintains program records on the students, decisionmakers are able to receive printouts to use for decisionmaking in terms of reallocating instructional resources, e.g., materials and teacher time, working with grouping practices, et cetera.

A fairly lengthy discussion regarding funding alternatives, by the Federal Government or local groups, or a combination, involved Representative Dan Glickman and Irving Anker, Chancellor of the New York City Public Schools and Board of Education, with the former asking this key question:

> Do you see the computer-managed instruction as the natural evolution of education, and is it affordable in terms of the massive costs of hardware and software that would be required all over this country?

Expanding upon Mr. Anker's affirmative response, Dr. Richard Vigilante, Director of the Office of Educational Statistics for New York City, explained the approach being taken in using Instructional Support Systems:

> One of the main problems that have faced the instructional and innovative programs, particularly those that are computer data oriented, has been that the very maintenance of the information files has been separate from the existing processes in the school for administrative data collection and recordkeeping. I think that is the reason why when you try to evaluate the programs the information simply is not there, because the cost to accumulate and process the information specifically for the evaluation of that program is prohibitive. What we are trying to do in New York City to support the management process within all the city schools is to institute within a 2-year period a citywide student data base combined with an instructional management system support mechanism to support a variety of services, administrative recordkeeping, attendance, and specific instructional services

The mechanism for implementing this type of program earlier had been described by Mr. Anker, in his prepared statement, when he discussed the creation of a new Office for Instructional Management, which would:

> * * * be capable of supporting school personnel in performing all essential functions associated with managing an educational system and achieving its objectives, including:
>
> 1. The provision of support to classroom teachers for the management and delivery of classroom instruction;
>
> 2. The provision of support to supervisors and superintendents for the management of instructional resources at the school building and district levels;
>
> 3. The evaluation of elementary and secondary educational programs in terms of cost and effectiveness;
>
> 4. The generation of information and reports for students, teachers, parents, school administrators, community groups, and state and federal agencies;
>
> 5. The provision of administrative data processing services for student record keeping, attendance reporting, scheduling and mark reporting required by individual schools.

The final witness on this first day of hearings was Harvey Garner, Community Superintendent for School District 18, who spoke of the experience gained in their use of ISS as a means for improving individualized instruction; this included evidence of its cost-effectiveness during the first year and further anticipated cost decreases. A description, provided by Mr. Garner, of the District 18 experience, appears in Appendix 10.

With Representative Stephen L. Neal presiding, the second day of hearings (October 6) focused on "the major innovations of the past 15 years in the field of computer assisted instruction," including the Computer Curriculum Corporation's drill and practice materials, the University of Illinois PLATO project, and the TICCIT project developed by Brigham Young University and The MITRE Corporation.

The leadoff witness was Dr. Alexander A. J. Hoffman, Director, Computer Science Program at Texas Christian University, who described himself as "not a developer, manufacturer, or marketer of CAI systems." His usage led him to raise certain questions and offer a definition:

> As a concept, computer-assisted instruction is very appealing and exciting. The computer is in its finest hour—flashing messages or graphic displays back to smiling students. However, as one listens to the presentations to follow one should attempt to balance between the enthusiasm of the developers and practical questions that should be asked about any technological innovation.
>
> We have to identify what it is. How does it work? Is it effective? Is it reliable? Is it still experimental? Are the effects short or long term? Are there undesirable side effects? How much does it cost? How does it compare with other means of accomplishing the same job? Is it easy to use? Will people accept and use it? Are there obstacles to widespread use? Will Government funding be required to develop it? Will it ever be commercialized? I shall now attempt to put these questions into the context of CAI.
>
> * * * * *
>
> To me the term "computer-assisted instruction" refers to computer delivered systems in which information is presented, questions are asked to determine comprehension level of the information or there is drill and practice to improve the skill with the material, reinforcement to responses are provided immediately: that is, the user is informed about the correctness of the responses, the user is tested, and the results are used to pace the student toward either remedial or new material. The learning experience is self-contained via the student-machine interaction. It is a computer based learning system that can be used in teaching many subjects, as you will probably hear later.
>
> The basic elements of any CAI system are curriculum materials, strategies of presentation, computer systems, and terminals which the students use.

The role of commercial concerns in supplying curricula in the form of CAI systems was developed during the testimony of J. P. Martin Clinton, Vice President, Computer Curriculum Corporation:

I think the best way to bring this forward is to describe a typical project which we might be supplying.

The school district is concerned about basic skills instruction in mathematics and reading to cover 1,000 students in four schools. Funds are available from a Federal source, specially targeted for improving grade levels in those subjects. The constraints are very important. The district wants to do something now. They have funds which are available for expenditure during this year, and they hope to produce measurable results between approximately 1 month from now and June 30, 1978.

When you see these constraints, I think you can understand the idea of having a system with programs and materials which are ready for use immediately.

It is not possible within the time constraints to establish a system where individual teachers are going to start the planning and development of materials. What is needed is a set of materials which have been shown to be effective in similar districts nationwide and therefore which present to the customer district a reasonable chance of producing the results they need.

The cost is also very important. A typical district has approximately $100 per child to spend on this project. This is an amount which is quite affordable and is within the range of available Federal funds.

Other experiences were shared with the Subcommittee by Dr. Nelson David Crandall, ESSA Project Director in the Los Nietos School District (Whittier, Calif.) and Dr. Martin Montano, the Superintendent for that district. Their study, "An Analysis of the Impact of Computer Assisted Instruction on a Program Designed to Ameliorate the Effects of Racial Isolation in the Los Nietos School District," was funded by the Department of Health, Education and Welfare.

The next witness was William C. Norris, Chairman of the Board and Chief Executive Officer for Control Data Corporation, who listed some of the PLATO system's salient features and advantages:

It permits direct, creative and responsive dialogue, on a one-on-one basis between the instructor and the student, or on a one-on-many basis.

Because the system can accept, react to, respond to and test the individual student input just as it comes from the student, PLATO is uniquely powerful in teaching problem analysis.

* * * the system is absolutely timeless in a testing and drill and practice mode. It can and does exercise students from kindergarten to PhD level.

Mr. Norris told the Subcommittee that PLATO education is delivered in a number of ways: through learning centers, the sale or lease of terminals installed on the user's premises, or "the actual sale of a complete PLATO computer system." An example of a program underway, he said, was that designed to "get inner-city unemployed youth in the 16–25 age group into productive and rewarding jobs;" the pilot project was in St. Paul. A related endeavor, reflecting the corporate thrust in the secondary education area, was noted:

> We have had four PLATO terminals installed in a Baltimore inner-city school for over 2 years, financed by Control Data. Results are proving that course offerings can be of high quality, and the lack of basic skills are much more efficiency corrected. Equally important, we have found that economically and educationally disadvantaged students can be motivated to learn, can enjoy learning and reduce their absenteeism.
>
> The program is now being expanded to 28 terminals spread among four schools. Half the cost of the expanded program will be paid by the Baltimore School Board, which will assume the full cost next year. Meanwhile, Baltimore will be seeking State and Federal funds to purchase a PLATO system.

During his testimony, Mr. Norris stressed the cost benefits of using PLATO, averring that for internal training within CDC, for example, the cost to provide employee training via computer-based education (CBE) is "less than 50 percent of the cost of traditional methods." After describing other CDC PLATO projects, the witness mentioned two potential programs in the continuing education area:

> 1. * * * putting PLATO terminals in co-op learning centers to teach their personnel in management and marketing and to deliver farm management courses to individual farmers.
>
> 2. * * * feasible within the next 4 to 5 years—will be PLATO CBE terminals in the home.

In response to a question by Dr. Wells of the Subcommittee staff regarding the "pattern of Federal R. & D. and trying to define appropriate roles for various government agencies vis-a-vis private concerns," Mr. Norris stated:

> What we are interested in really is the general model by which, if the Federal Government is going to support research and development of this sort, what is the ultimate coupling mechanism to the marketplace?

Further commentary on PLATO then was furnished by Dr. Donald L. Bitzer, Director of the Computer Based Education Research Laboratory at the University of Illinois (Urbana), and this was augmented by a 20-minute demonstration before the hearing audience. Following this illustrative activity, possible model plans for CBE funding by the Federal Government were discussed, and additional understanding provided of the cooperative arrangement between CDC and the University of Illinois for PLATO distributive services. Appendix 11 features a narrative history of PLATO plus a description of its impact to date and identifiable future implications.

The final segment of this hearing revolved around testimony by Dr. John Volk, Director of Engineering for the Educational Systems Group of the Hazeltine Corporation, followed by Dr. C. Victor Bunderson, President of the World Institute for Computer Assisted Teaching, Inc., both of whom addressed the characteristics and services of the TICCIT (Time-shared, Interactive, Computer-Controlled Information Television) system. Hardware, software, and courseware were described with several examples of the system's utilization.

The history and major aspects of TICCIT are included as Appendix 12. The session ended with a wide-ranging discussion of the tradeoffs inherent in the use of such systems in the instructional environment.

With Representative Scheuer once again presiding, the third hearing session (October 12) had as its topic "The Future: Research, Development, and Planning." The first witness was Dr. James C. Emery, President of EDUCOM (Inter-University Communications Council), who spoke of the dramatic improvements in electronic technology, pointing out that:

> * * * in three decades in the computer field we have seen six orders of magnitude, six tenfold increases in computer power and we are only just now beginning to see some of the impacts that they might have.

He proceeded to discuss the consequences of such technological developments:

> First of all, the startling advances in electronic technology will permit very widespread diffusion of computer hardware. The computer here is a $600 item. That is representative of the way the technology is going. When I first got interested in computing some 20 years ago, the computer I started out with had a monthly rental of perhaps $3.000 to $4,000. This $600 machine is more powerful in many ways than that machine was back in those days. So we will see very widespread diffusion. Everybody who has a need for a dedicated computer of that sort will be able to get access to one. The real problem will be the high cost of personnel to develop the system capable of using these systems. There is some danger in putting a lot of money into hardware and as a result adding to the total cost in education because of the personnel cost to operate. This I think gives a very strong incentive to various mechanisms for sharing the software and data bases necessary to take advantage of the very low-cost hardware.

Next, Dr. Emery told about the network called EDUNET, "which serves a national market linking colleges and universities so that they can share computer resources." Later, in a dialogue with Representative Scheuer and others he explained that "person-to-person interaction" is another basic reason for having a networking arrangement; in particular he cited teleconferencing and electronic mail systems. An example of the latter capability, discussed subsequently, was NIMIS, which provides access to instructional material for handicapped children, but which might be expanded to include "access to specialized human resources."

It should be noted that in the formal statement of Dr. Emery, a number of important policy issues were identified, all of which should be dealt with at the Federal level:

Funding research and development of educational technology.

Funding the operational phase of delivery systems.

Review of Internal Revenue Service regulations in order to encourage greater sharing among tax-exempt educational institutions.

Review of Federal Communications Commission regulations in order to encourage electronic mail and similar communication services.

Early in his oral testimony, Dr. Seymour Papert, Director of the Artificial Intelligence Laboratory at MIT, stressed that "we are on the verge of a real critical situation which I think deserves to be classified as a national crisis." After warning that "there will be serious danger not only of a waste of an opportunity but also an aggravation of social problems within the United States and the U.S. position in the international area," he narrowed his focus:

> What I would like to do is first of all to try to convey to you a sense of how the computer presence will be able not merely to assist or improve traditional institutions like schools in teaching traditional subjects but will radically change what we teach, where we learn it, and how we learn it. And to make the point I would like to set up some analogies to use as images.

Representative Scheuer then talked about the failure of students at all levels "to optimize their talents," and that the educational environment--in the elementary and secondary schools—is often "a sort of Death Valley:" Dr. Wells of the Subcommittee staff had this query:

> Dr. Papert, you mentioned the virtual absence of any significant work in the social sciences regarding the implications of some of the things that you see on the horizon. How best do you see this being formulated, an approach being formulated? Does the computer industry which is spearheading this have a responsibility to try to hook up with the social scientist or do the social scientists have to barge in and say what the hell is going on here?
>
> You mentioned some types of conditions now. Are you thinking of something along the lines of the Kennedy-Johnson Commission on Automation Technology in the Economy?

Next to appear before the Subcommittee was Dr. John Seely Brown of the Computer Science Division at Bolt, Beranek & Newman, Inc., who told of efforts underway in his laboratory—and that of Ira Goldstein at MIT—to provide "computers with an ability to understand the learner . . . his strengths and weaknesses as well as his style of learning." This effort aimed at designing Intelligent Instructional Systems was based, he said, on two central assumptions:

- first, representing true problem solving expertise within the computer, and
- second, good diagnostic and modeling capabilities of the particular students that the system is engaged with.

Among the prototypes he mentioned was SOPHIE, which:

> * * * presents the user with a simulated circuit to be fixed. The user can make any measurements he wishes, replace any parts. SOPHIE observes these measurements and employs a deep understanding of electronics to decide whether a given

> measurement is needed or a given part replacement justified. Its tutorial function is to discuss these observations with the novice technician. In essence, it is a troubleshooting consultant. The student can explore the device with no possibility of harm, in a private setting.

Also, he talked about computers in the home, and how "kids want to play these sexy games . . . maybe they want to learn how to program the machine so they can actually do something else with it."

> But what we're really missing is what I think of as a cognitive component that is on top of these games—a coach or a kibitzer, a kind of personalized tutor that can take the kid's enthusiasm about a particular educational game and point out to him at critical times what he's doing right or wrong and what is e' ·ationally or intellectually significant about the particular situation he is currently confronting.
>
> Very often if you put a kid in front of a computer and have him play a probability game or anything like this, you will find he gets stuck pretty quickly. He zeroes in on a plateau of his skills. He doesn't see the real challenge and that, in fact, the particular game situation he confronts is an illustration or instance of some abstract idea he has been taught in school. He has been taught abstract things, but he has seldom been provided with a concrete realization of these abstract concepts.

Dr. Brown's prepared statement contained useful information on "The History of Intelligent Instructional Systems."

Dr. Arthur W. Luehrmann, Associate Director, Lawrence Hall of Science at the University of California (Berkeley), encapsulated his testimony content in five sentences:

> 1. The United States is the world leader in manufacturing microelectronic hardware.
> 2. That technology makes it possible today to deliver powerful personal computers to millions of individuals.
> 3. The biggest single impediment to the further growth of this industry is the fact that the vast majority of Americans are uneducated in the use of a computer.
> 4. To carry out the educational task ahead will require a substantial investment in research, development, planning, and delivery.
> 5. The private sector is not organized to make significant investments in the education of the public.

Dr. Luehrmann and the Chairman then discussed the several roles of the computer in the home—e.g., serving the elderly who are homebound—and how people find it satisfying to communicate in various ways. His discourse on learning to use a computer centered on how individuals must "structure their thinking so that it can be communicated to a computer," and then he said:

> What tools does a person usually use to think about a problem? There are just a few—logic, mathematics, natural language (English in this country). One writes words about a problem. One may be able to express a problem as a set of

mathematical equations. One certainly uses logic. A computer program is yet another way of representing one's understanding of a problem. One can write the problem down as a set of procedures—go through this process and repeat it some number of times; then do this process; then test to see if a certain variable has reached a certain value. If so, go do this. If not, do that.

The fourth day of hearings (October 13), presided over by Representative Robert S. Walker, featured presentations by representatives of various Federal Agencies concerned with funding research, development, and demonstrations in the subject field. The initial testifier was Dr. F. James Rutherford, Special Assistant to the Director of the National Science Foundation, who would appear as a witness during the October 1979 hearings before the House Subcommittee on Science, Research, and Technology. Dr. Rutherford presented an overview of past and planned NSF programs and research efforts directed at the use of computers in science education and resource improvement projects. During an exchange with Representative Walker, he offered a personal view:

> * * * I suppose there is a danger in the use of any new technology in education. It would be more of a danger if educators were better able to apply technology than in fact they are. But I think the point is well taken. My own bias as an educator now is that in the elementary school the computer's role in the school should be solely as a tool, not as an object of instruction. And if it can help children learn fundamental thinking, logic, and use of numbers, how to express ideas, how to sort information, that is contributing basic education, and that is its role.

The next witnesses were Dr. Arthur S. Melmed—who would also offer testimony during the 96th Congress hearings—and Dr. Thomas G. Sticht, both of the National Institute of Education. During their statements and discussion with the Subcommittee, they highlighted the R & D activities at NIE regarding use of computers in elementary and secondary education administration and teaching, also, they cited the need for research to assess the implications of computer technology. Four specific activities comprised their agenda:

> (1) the evaluation of existing technologies for computer-managed education, computer-assisted instruction, and mathematics instruction;
> (2) exploratory research and development of educational applications of the new, low-cost technologies;
> (3) research and development of software to create a new generation of "smart" computers; and
> (4) studies on the impact of computers on the individual and society.

Dr. Harold F. O'Neil, Program Manager for the Cybernetics of Instructional Systems, Cybernetics Technology Office of the Defense Advanced Research Projects Agency, focused on the needs and plans for new computer-based educational systems development and evaluation in the field of military training. He told how R & D on computers in education and training had been concentrated in three areas:

(1) reducing average training time through techniques which permit instruction to be individually tailored to a wide range of student aptitudes;

(2) reducing the demand for "people involvement" in the design, development, and operation of military instructional systems through computer support; and

(3) providing realistic job-related experience using relatively low-cost computer-based simulations as substitutes for high-cost operational systems.

Among the systems used in the DARPA environment: a large-scale CAI system with a central computer and remote terminals (PLATO IV), a dual mini-computer CAI system (TICCIT), a multi-mini-computer CMI/CAI system with a large central computer (Advanced Instructional System, AIS). Dr. O'Neil later suggested that an identifiable need in elementary and secondary education is for a series of "testbeds" each of which would:

- serve as an instrumental facility to test ideas in a computer-based education, and
- serve as a center of excellence.

A featured portion of his testimony described his agency's experience with PLATO IV, in which $4 million was invested, plus another $10 million provided by NSF. The evaluation data revealed: "equal to or better performance and 40-percent time savings . . . Student and instructor attitudes were very positive."

The final witness at this hearing was Dr. Glenn L. Bryan, Director of the Psychological Science Division, Office of Naval Research, who described the mission of his division: "to create basic knowledge and understanding which will lead to new ways and better ways to utilize equip and manage naval personnel of the future." After discussing various aspects of using computers in an instructional setting, Dr. Bryan reflected that:

The passage of time, and hopefully some of the actions that we took back in the early sixties have led to the development of a community that is much more conversant with each other, much more tolerant of each other's views, much more aware of the potential contributions of the other disciplines. And I think we are in a far better situation now to develop better computer-based instructional systems.

My only plea is in our effort to get on with the exploitation of computer-based systems and that we continue to try to locate ingenious, creative people whose talents can be brought to bear on the problem.

The conversation then turned to what constitutes a "computer revolution," and "whether the machines will save us." Dr. Wells offered a context for this often-discussed occurrence:

Ten thousand years ago, we developed agricultural science in a rudimentary fashion. Six thousand years ago, roughly, we developed language and mathematical capabilities which began to transform society greatly. Only within the last 300 years have we developed science in a modern sense. The world has changed radically in the last 300 years, and in the past 50 years since then a large-scale intervention by Government in supporting research and development has led to a lot of change in a real revolution sense. So I think that is the context in which we understand the use of the word "revolution" here in that we have been riding the tides of these revolutions by and large rather than understanding what is happening.

On the fifth day of hearings (October 18), attention was turned by the Subcommittee to the role of computers in the education of the handicapped. Representative Scheuer, presiding, reminded the participants that Congress was interested in "the cost-effectiveness of our methodologies and our modalities for dealing with kids with special education needs, especially handicapped children."

First to appear was Robert B. Herman, Associate Deputy Commissioner, Bureau of Education for the Handicapped at DHEW, who was accompanied by Dr. Frank Withrow, Special Assistant to the Deputy Commissioner of the Bureau. In his prepared statement, Mr. Herman stated that "The use of computers will undoubtedly figure heavily in obtaining an equal educational opportunity for all handicapped children." and he cited the aim of P.L. 94–142 (Education for All Handicapped Children Act of 1975) to ensure "a free appropriate public education" for every child "with a physical or mental impairment." He then talked about two specific uses for computers in the education of the handicapped:

> One is the use of computers to compensate for the handicapping condition. Computer-generated speech, for example, can be used by persons who have a limited ability to speak. Such systems can be activated by either manual or oral output. The reverse of this example would be the turning of print into speech to enable the blind to have access to the printed page. The technical problems of conversion of print to speech are less difficult than the transformation of speech to print.
>
> *　　　*　　　*　　　*　　　*
>
> The second and most rapidly developing use of computers in the education of handicapped children is computer assisted instruction in regular school programs. The computer can perform two missions. First it can be the patient, nonthreatening instructor that can repeat over and over again for a child with a learning problem. It can provide a child who is limited in his expressive abilities new ways to express his ideas and thoughts.

A series of contracts in various areas were described, including one with Gallaudet College and the Computer Graphic Center of Ohio State University to develop materials in three dimensions, which could benefit deaf children. After mentioning such devices as the Kurzweil Reading Machine and the Optacon sensory reading machine for the blind, the witness sought to establish a context for considering this crucial area:

The point of the matter is that as Congress has mandated in legislation the placement of the handicapped child with his normal peers wherever possible, at any opportunity possible, in the so-called least-restrictive environment, it becomes even more important that handicapped children be able to work at their own pace, to have an opportunity to have material presented for them with their own ability to accept it, and to have materials presented to them in a different degree, or in varying degree, of styles and modes.

So we are very much interested in computers and the use of computers in education for the handicapped, especially in the computer-assisted instruction area, where handicapped children, learning disabled children, as well as the broad range of mentally retarded and other kinds of children with difficulty in learning processes have an opportunity for this self-generated, self-paced process.

In addition, we have used the computer to help train regular and special teachers in the in-service and the pre-service training of teachers—teachers who are in schools where they do not normally come into contact with severely-handicapped youngsters, youngsters who are at the low incidence of handicapping conditions.

Also, computer-assisted instruction has been used to train teachers in-service at their home districts, where teachers are not close to a metropolitan area where they can easily come to an in-service training program, or spend a week or 2 weeks or a weekend with experts.

Next to appear was Raymond C. Kurzweil, President of Kurzweil Products, Inc., together with Barry Unger, Executive Vice President for that firm. Along with monstrating this device, "designed to convert printed material to spoken word speech," Mr. Kurzweil highlighted some of its functional characteristics:

The machine is able to go back and repeat words or spell words out.

* * * this new model will go up to 250 [words per minute]. Experiments with compressed speech show that people can understand it up to 250, 300 words a minute.

You have to turn the pages yourself.

The witnesses said that 12 machines currently were in use, with 35 more being constructed for placement over the next 10 months. Funding was received from different Government and private agencies, and several settings chosen for situating the machine: public schools, offices, other professional milieu. A brief description of the Kurzweil device, taken from Mr. Kurzweil's formal statement, constitutes Figure 8:

FIGURE 8.—Description of the Kurzweil device

The Kurzweil Reading Machine converts ordinary printed materials, such as books, magazines, letters and reports into spoken English at approximately 150 words per minute. The system reads most common styles and sizes of type, handles many forms of print degradation, and thus allows blind and visually handicapped persons to read ordinary printed material rapidly, with minimal training required, and without fatigue.

The user operates the device by placing printed material face down on the glass plate which forms the top surface of the scanning unit. He then presses the "Page" button on the control panel to activate the reading process. A specially designed scanning system we developed scans the page and transmits the image in electronic form to an image enhancement system. This system, which we designed and implemented in hardware, increases the contrast found on the page and brings out particular features that improve the recognition process. The enhanced image, now in digital form, is transmitted to a small computer contained within the reading machine which contains unique programs we developed to separate the image into discrete character forms, recognize the letters on the page, group the letters into words, and compute the pronunciation of each word. Pronunciation is accomplished through the use of over a thousand linguistic rules plus two thousand exceptions to the rules stored in the computer's memory. Additionally, a stress contour over each sentence is computed by a set of syntactical rules.

An important feature of the reading machine is its user controls. For everyone, sighted or blind, reading is properly an active rather than a passive process; one re-reads interesting or difficult passages, pauses at unfamiliar words, skims the page to find material of particular interest, and so on. The Kurzweil Reading Machine is operated by the user with a set of 33 keyboard-mounted buttons to allow the user to effortlessly make these choices. For example, the machine stores in its memory the last 300 characters that it has scanned, allowing the user to back up and hear words over again, have particular words spelled out, and other functions.

Dr. Geoffrey Nelson and Mr. Vito Proscia, both vice presidents of Telesensory Systems, Inc. were then called to give testimony. The former provided key information on the Optacon device and the corporation which created it:

> TSI was incorporated in 1970 in Palo Alto to manufacture and distribute the Optacon, a print reading aid for the blind. The Optacon, which is an acronym for *OP*tical *TA*ctile *CON*verter, was developed in eight years of research in the integrated circuit laboratory of Stanford University, and at Stanford Research Institute. Using the latest developments in integrated circuit technology, the Optacon was made small enough to be completely portable and inexpensive enough to be individually owned. Word of TSI's Optacon spread quickly, and as a result there are now almost four thousand Optacons being used by blind people in over forty countries world-wide. TSI is now recognized not only for its technological expertise, but also for its ability to identify, educate, and support a very specific handicapped end user with a complex high-technology product, in a climate of limited funding. Since TSI's modest beginning, the company has grown to a current level of employment of nearly 150 people with several product lines. Our present principal devices are sensory aids for the blind, but our general area of interest is high-technology aids for the handicapped.

Mr. Proscia, himself blind, then demonstrated the Speech-Plus Calculator, a "calculator that talks" and which had been modified to be used in the classroom by blind children. Its evolution had only been possible, it was explained, because of developments in the state of the art of microcomputers.

In spite of existing Federal legislation, there are problems associated with Federal Government participation in the development of such equipment, and the varying interpretations by State departments of educational rehabilitation regarding its use. The witnesses in their prepared statement offered three recommendations in this regard:

> *First*, the Rehabilitation Services Administration is currently precluded by law from funding any activities, including development of devices of these types, to private industry. There is no such limitation in the educational legislation sector. Yet the Office of Management and Budget has recently expressed the Government's general policy of reliance on the private sector for needed goods and services. Telesensory Systems actively supports House Bills HR 7735 and 7736 and Senate Bill 1905, all of which remove this funding restriction from RSA legislation.
>
> *Secondly*, it is essential, particularly in the educational and vocational aspects of such devices, that the Federal Government play a principal role in the dissemination process. Because of the limited market for such high-technology products, the prices to the handicapped consumer are unfortunately higher than any of us would like, and thus federal funding is important if such technology is to become effectively used on a wide basis. Existing federal legislation is in the right direction but a more aggressive approach by both the legislative and executive branches would greatly improve the process.
>
> Our *third* recommendation is to suggest that the Federal Government should play an active role in the development process. Historically, most devices of this sort have failed to reach the marketplace because the market size for devices for the handicapped does not in general support the extensive development monies required to bring such products to fruition. All private industry must of necessity view each project from the point of view of its financial merit, and most products for the handicapped fail that test. However, with federal support for the development process, the manufacturing and dissemination of such devices at a reasonable price become much more realistic. We have developed a financial analysis which I would like to include in the record, which shows that the Federal Government receives more in tax dollar revenue from the employment of people using these devices than it pays to private industry to support the development process. In other words, it's an "everybody wins" situation; private industry has a financially viable product, the government succeeds in educating and rehabilitating handicapped people

with a *positive* cash return, and most important, the handicapped individual lives a more productive and satisfying life.

A demonstration of the Optacon equipment was then executed by Mrs. Carol Gillespie, who is blind. It was noted later in the discussion that the cost of the Optacon has dropped from $15,000 to $3,000. Mr. Proscia commented upon the limited market and observed that the "major cost the company is facing is not the manufacturing cost, but it is the cost required to disseminate and to expose the equipment to the population in which we're interested." It was established that while there are approximately one million persons who are "legally blind," only about half of these are on the lists of the Rehabilitation Services Administration.

Mr. Gregg Vanderheiden, Director of the Trace Research and Development Center at the University of Wisconsin (Madison), was the next witness. In his testimony, which focused on the problems of those with severe communication handicaps, he set forth in graphic form three types of computer use (as shown in Figure 9). He also distinguished between "Educational Aids" (system, etc.) and "Aids to Education":

- "Educational Aids" here refers to materials, devices, teaching machines, etc. which are designed for the purpose of facilitating the teaching/learning process.
- "Aids to Education" refers to devices which were not designed for educational purposes but which are necessary in order to receive an appropriate or effective education.

In his oral testimony, Mr. Vanderheiden ended by quoting John Eulenberg of Michigan State who had observed that: "These aren't severely handicapped individuals, they're individuals who are experiencing a handicap, and in this case a severe handicap."

The succeeding witness was Dr. Sam C. Ashcroft, Director of the National Center on Educational Media and Materials for the Handicapped at Ohio State University. The central thrust of this witness's testimony was concerned with the development, over the past three years, of the National Instructional Materials Information System (NIMIS) at Ohio State University. This system, which is described more fully in Appendix 13, handles descriptive information concerning more than 35,000 selected instructional media and materials of various kinds. A special NIMIS Thesaurus, "a dictionary of descriptors" with more than 800 terms, facilitates the detailed specification of instructional materials in order to more precisely meet specific instructional objectives. Dr. Ashcroft also called the Subcommittee's attention to a new portable braille recorder, brought to this country from France. It is a "4-pound device that records on audio tape, along with audio material, braille information which can be read out in a 12-cell display from the same reading and writing device."

Dr. Seymour Papert, Director of the Artificial Intelligence Laboratory at the Massachusetts Institute of Technology," next was called to testify, and he demonstrated a device which could help cerebral palsy victims elicit a picture or writing from the machine, or even music.

THREE TYPES OF COMPUTER USE BY
INDIVIDUALS EXPERIENCING HANDICAPS

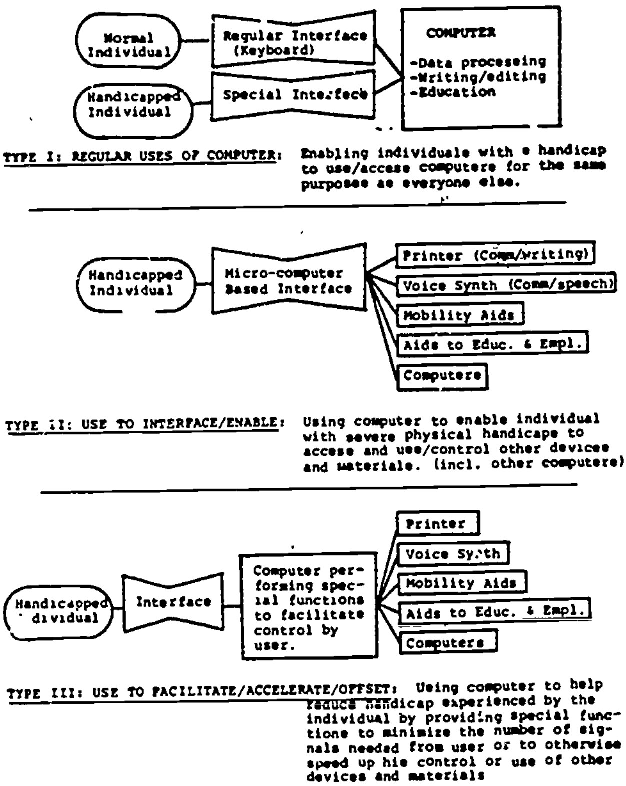


FIGURE 9

And these results can be stored for future retrieval and use. Dr. Papert spoke, in simple terms, of how such a handicapped person can identify with an "animal" on the screen, and get it to perform certain acts. "And so this knowledge that he's been building up by observing the world gets channeled into a form where it's useful, where it is instructional." Citing the limitations of funding and other resources, the witness talked about the difficulties of implementing innovative approaches or techniques into a system that was designed to function in another way:

Now, in this case we have an education system that works mainly through interchange of words between teachers and students, and we make a machine where we automate that particular function. We make a new device which sits inside an otherwise unchanged—which expects to function inside an otherwise unchanged education system.

Whereas, in fact, a reconceptualization, a rethinking in systems terms, of the whole process of education, of what people should learn and how they can learn it, leads to a whole different picture of what can be done. But it's something which no individual group is very easily able to do in principle, and also because—this is my main recommendation, the main recommendation point I want to make—because of the kind of scale of funding which has become established in this business.

It becomes much easier for people to make other devices which fit into the otherwise unchanged system than for anybody to be concerned with the change of the whole system. As a result, we see more spectacular developments in areas like these machines for the blind, where the particular special need is such that making a particular device does in fact so transform the opportunities for the individual that you don't have to think in terms of changing the whole system.

He then made the recommendation that:

* * * we as a community, that Congress treat it as a matter of extreme national urgency, to consider the systems aspect, the holistic, global redesign problem of education as a whole.

The last witness to appear before the Subcommittee during the fifth hearing was Dr. Dustin H. Heuston, Chairman of the World Institute for Computer-Assisted Teaching, an individual who would later testify at the joint hearings held in 1980 by the House Subcommittee on Select Education and the House Subcommittee on Science, Research and Technology. Although Dr. Heuston talked throughout his presentation about the videodisc, this was done within a broader context. He stated that the videodisc combines the three most powerful technologies that have been used in education: the book, television, and the computer:

The book—inexpensive . . . portable . . . available, highly replicable

Television—has color, sound, and motion . . . can use plot and characterization

There are some extraordinary weaknesses to television as an educational format. In terms of learner productivity, it's a disaster. A student has to sit and wait for the information to come through in serial sequence. They cannot stop it, they cannot interact with it, and therefore they become very passive. It cannot give trials to the student, cannot freeze a frame, and has limited depth of instruction in terms of what a narrator is saying. Therefore, it's very poor for learning productivity.

The computer—has random accessibility . . . can ask a student a question; the student responds. The computer calculates, feeds back an answer immediately . . . the computer output format is a disaster in terms of emotional excitement.

Now, what the videodisc will do basically is to combine these three in one device. You will be able to be taking instruction with, say, 3-, 4-, or 5-minute bursts of a movie, with a narrator talking about it. Then the videodisc will stop and the user will start an instructional sequence by using special keys.

If, for example, to give you an idea of the power of that information we'll be able to use here, by taking out 10 seconds of a half hour production, we'll be able to insert 300 individual still frames in color, with excellent learning theory behind it, and with special keys to take students through it. So we will be able to salvage the power of the television production, with color, sound, and motion; then it will freeze, and the user can go into a very interactive instructional format with drilling practice.

The second generation videodisc will have a computer built inside so as the student responds, the answer will be processed automatically. There will be automatic feedback. The student will be given responses back predicated on their previous trials. It will be an ideal instrument.

Now, there are some other aspects to this which are very exciting. A record will cost about 50 cents to make. It will not wear out, because it's read by a laser beam. Therefore, we will be able to distribute in great quantities these disks throughout the country.

On a special chart, Dr. Heuston presented a graphic overview of the strengths of the three traditional forms (see Figure 10):

BOOK	
Strengths	Weaknesses
1) Random access.	1) No interactivity.
2) Low expense.	2) Lack of motion and sound
3) Availability.	3) Requires literacy.
4) Replicability.	4) Fixed level of difficulty.
	5) Usually in one language.
	6) Requires high learner motivation
	7) Low learner productivity
FAIR LEARNER PRODUCTIVITY FAIR PRESENTATION FORMAT	

TELEVISION (MOVIES)	
Strengths	Weaknesses
1) Audio capability.	1) Serial presentation, no random access ability
2) Visual format allowing photography.	2) Inability to freeze a frame
3) Motion capabilities.	3) Inability to give trials with feedback.
4) Use of plot & characterization.	4) Passive system. User cannot initiate any materials
5) Ease of availability.	5) Limited depth of instruction
6) Low expense.	6) Extremely poor learner productivity
POOR LEARNER PRODUCTIVITY EXCELLENT PRESENTATION FORMAT	

COMPUTER	
Strengths	Weaknesses
1) Random access ability.	1) Lack of audio.
2) Ability to give trials with feedback	2) Poor presentation format. primarily black & white
3) Active system. Ability to compute & run programs	3) Lack of motion and photography.
	4) Lack of characterization & plot abilities
	5) Expense
POOR PRESENTATION FORMAT EXCELLENT LEARNER PRODUCTIVITY	

VIDEODISC WITH MICROPROCESSOR

(STRENGTHS OF ALL THREE TRADITIONS)

FIGURE 10.—Charted strengths and weaknesses of book, television and computer technologies

The remainder of the session was devoted to a discussion between the Subcommittee and its witnesses of appropriate funding policies, the difficulties of introducing new tools and techniques into learning situations, and alternative strategies of planning for better, more responsive technology-supported educational systems.

The final day of hearings (October 27) was dedicated "to the special problems posed for educators by the gifted child on the one hand and the disadvantaged child on the other," in the words of presiding Representative Scheuer. He then spoke of the enormous investments made under Titles I and III of the Elementary and Secondary Education Act (P.L. 89–10, as revised) but of the concomitant drop in learning scores.

> So there is a great deal that can be accomplished. The business of raising functionally effective people who can perform in a society that is increasingly demanding higher and higher levels of sophisticated skills is an absolute must for this Congress and for our society.

A comparison was drawn by the Chairman as he talked about the success within the Soviet Union of identifying gifted children and treating them as a special resource. In the United States there is a "finite education pie," both in the public and private sectors, so in our education system "we have to achieve some kind of more sophisticated decisionmaking on how we allocate resources."

The first witness before the Subcommittee was Dr. Patrick Suppes from the Institute for Mathematical Studies in the Social Sciences at Stanford University, who commenced by saying that "One of the most encouraging things in terms of cost/benefits are the increasing cost reductions in the delivery of instruction by means of computers." Dr. Suppes talked about his experience, since 1963, in dealing with "a variety of special populations, disadvantaged, handicapped, and gifted." and noted that:

> * * * the first school system in the world to have every elementary-school child at a terminal for some supplementary instruction in basic skills by computer was McComb, Miss.

Continuing, he told of other programs, including one in rural Appalachia, which emphasized such basic skills as reading and mathematics. Computer-assisted instruction is not a panacea, he opined, but it can be effective because it "is individualized, and it is highly interactive. It is addressed exactly to the need and level of achievement of the student at a given time." Dialogue between Representative Scheuer and the witness ensued, which touched on the need for an early identification of the gifted child based on testing and school performance. Options for teaching gifted children were explored—university campus, public school, individual home—and Dr. Suppes felt that it would be economical to handle gifted students by placing terminals in their own homes, when working with a population segment of more than 200,000 persons. Problems connected with institutionalizing such an effort are complicated since a long-term (perhaps 12-year) effort is optimum. Representative Scheuer voiced the difficulty of getting Congress to consider such an endeavor, since it normally operates within a two- or three-year time framework. Also, he said, school districts are wary of going through major structural reorganizations "without some kind of assurance." The difficulties of the Head Start and Job Corps programs were mentioned.

Subsequent discussions between Dr. Suppes and the Subcommittee—especially staffer James Gallagher—focused on future possibilities for CAI development and use, including suggested Federal support opportunities, and the anticipated cost-effectiveness of computer technology as applied to education. Also, the element of involving potential students was raised, with Dr. Suppes relating how 20 percent of the adult population in Orange County is involved in at least one course at the community college level:

> * * * the community colleges are effectively marketing instructional courses that people want * * * It is obvious that they provide a service that completely responds to a felt need on the part of the population.

Next to be called by the Subcommittee was Dr. Sylvia Charp, Director of Instructional Systems, School District of Philadelphia, who described the effort in that city to utilize computers in instruction.

> Results from the mathematics and reading programs last year with over 3,000 elementary school students have shown that the educational gains of disadvantaged students using the computer not only match but surpass the gains of children taught in regular classes.

She told of heightened response by "reluctant learners" among the 10,000 secondary school students who were exposed to computer use in such subject areas as mathematics, science, social science, and business. The Chairman and Dr. Charp discussed intensively the nature of the Philadelphia school population—two-thirds disadvantaged and 60 percent minority students—and the difficulties of getting support from school administrators and teachers. The details of students' use of terminals in terms of time available and costs followed, and Dr. Charp at one point recommended that an "all-technology school where we could explore technology to the furthest and see how far we can go in education with the technology that is around today" be established.

The third witness of the day was Dr. Dorothy A. Sisk, Director of the Office of the Gifted and Talented at the Bureau of Education for the Handicapped. In her statement, she told of the mixed response by a group of 1,000 educators to her talk at a national conference [120] on the subject of "The Age of Technology: An Invitation and a Challenge to Gifted." Many persons seemed fearful, she said, when they heard of CAI programs for elementary gifted children in physics, math, algebra, and chemistry. Then, the witness told of several instances where universities were working cooperatively with local schools in providing computer-assisted education, after which she and Representative Scheuer discussed the potential of existing legislation—the Education for All Handicapped Children Act—in this area:

> Computer-assisted instruction also will help in terms of the States that are using Public Law 94–142 to serve their gifted, in other words, the language from Public Law 94–142. In approximately 20 of our States, gifted children are served under the rubric of exceptional child education. Consequently, Public Law 94–142 language serves the gifted as well as the handicapped. Two advantages are coming out of several of

[120] Computers and the Learning Society, p. 607.

the programs that are using computers. One is that it helps in terms of individual programing for the children. In other words, as we become more skilled in diagnostic prescriptions of gifted children, knowing the child's ability level, the child's achievement level, the child's self-concept, creativity, strengths and weaknesses, and as we become more skilled in programing strategies, this information can be fed to computers, thus providing an individual plan for an individual gifted child.

Second, in serving the gifted child in the regular school there is spillover value to the total program. A concern that I see particularly in inner-city areas—and New York City is a prime example of that—where we would expect 3 to 5 percent of the school population to qualify as gifted. In New York City, for example, that would be about 50,000 children.

The final witness at this hearing was Dr. Harvey J. Brudner, President of HJB Enterprises, who presented a briefing on and initial results of a current assessment study on instructional computer support programs. In particular, he noted the lack of comprehensive statistical summary data relating to computer support in an instructional environment:

Extent of usage
Regional distribution
Numbers of students and grades
Academic subject areas
Categories of instructional use
Types and Number of terminals
Documentation of gifted and disadvantaged subgroups

Augmenting his oral testimony were two papers;

1. "The Past, Present, and Future of Technology in Higher Education," which appears in its entirety in Appendix 14; and
2. "System Study of Primary and Secondary Education with Emphasis on Urban Core Areas in New York State." [121]

With this presentation and supporting material submitted, the Subcommittee concluded its hearings on "Computers and the Learning Society." Subsequently, in June 1978, a report with that title [122] was issued which featured a series of recommendations from participating witnesses and representatives of government agencies in the field. In addition, this oversight effort by the House Subcommittee on Domestic and International Scientific Planning, Analysis and Cooperation cogently described by CAI and CMI systems and their technology, and reviewed the application of these innovative approaches to education for the handicapped and the gifted.

One other legislative action during the 95th Congress was of note: the passage of the Education Amendments of 1978 (P.L. 95-561),

[121] Computers and the Learning Society. p. 626.
[122] U.S. Congress. House. Committee on Science and Technology. Subcommittee on Domestic and International Scientific Planning, Analysis, and Cooperation. Computers and the Learning Society. Committee Print, 95th Congress, 2nd session. Washington, U.S. Govt. Print. Off., 1978. 48 p.

wherein Title II stressed the need to utilize new technologies to improve and develop basic skills and Title XI granted assistance for children's educational television.

Hearings on Information Technology in Education (96th Congress)

In considering the role of information technology in education, two sets of hearings were held in the House of Representatives during the 96th Congress (1979–1980). The first hearing occurred on October 9, 1979 under the aegis of the Subcommittee on Science, Research and Technology of the Committee on Science and Technology, and was chaired by Representative George E. Brown, Jr. This one-day hearing focused on "information and communications technologies appropriate for educational application,"[123] with especial attention to H.R. 4326 which would establish a National Commission to Study the Scientific and Technological Implications of Information Technology in Education. This bill, introduced by Representative James H. Scheuer, was referred jointly to the Committee on Education and Labor and the Committee on Science and Technology.

The second series of hearings, augmented by a technical workshop, were conducted on April 2–3, 1980 under the joint auspices of the Subcommittee on Science, Research and Technology and the Subcommittee on Select Education.[124] Representative George E. Brown, Jr. served as chairman of these hearings, with Representative Carl D. Perkins (Chairman of the Committee on Education and Labor) functioning as co-chairman. The announced objectives of these sessions were to enhance the awareness of the Congress, the Executive Branch, and the private and public sectors of:[125]

- the potential educational benefits of new information and telecommunications technologies, and
- the possible social and economic impacts resulting from the widespread use of these technologies in the educational process.

In order to draw upon the widespread interest and experience available in this area of burgeoning concern, a technical workshop consisting of 125 public and private sector participants was held during portions of April 2 and 3. The *modus operandi* featured deliberations by six structured "discussion groups:

Group 1—Elementary and Secondary Education
Group 2—Post-Secondary Education
Group 3—Adult Education
Group 4—Special Education
Group 5—Development of Information Technology
Group 6—Public Planning for Education in the Information Society

Through this mechanism, the sponsoring subcommittees could derive specific, useful commentary in the form of issue identifications and recommendations for action. Ancillary to the workship were a series of demonstrations by university, commercial, and government groups which have been developing computer-assisted tools and techniques for use in education (see Appendix 15).

[123] Information and Communications Technologies.
[124] Information Technology in Education: A Joint Hearing and Workshop.
[125] Information Technology in Education. A Joint Hearing and Workshop p. 3

The testimony solicited and received during both series of hearings reflected the broad spectrum of concern and involvement on the part of both the public and private sectors. As noted in Figure 1, those organizing the hearings sought representation from Federal Government and academic institutions with policy and program responsibilities, private sector entities concerned with research and development as well as the commercial marketing aspects of this area, and educational groups (including the media) responsible for providing computing, audio-visual, library, and other research support services. All formal testimony presented at the two series of hearings has been published in two volumes, as shown in the Selected References' section (Appendix 16) of this study. Listings of all key participants involved in the October 1979 and April 1980 hearings are found in Appendixes 17 and 18.

During the 96th Congress, there were other actions anent the role of information technology in education which warrant mention:

. Passage of the Department of Education Act (P.L. 96–88), with the first Secretary of Education being sworn in on December 6, 1979. An Assistant Secretary for Educational Research and Improvement was created to be responsible for research, development, dissemination, and assessment activities.

. A three-day series of panels and workshops on "Application of Technology to Handicapped Individuals" was held in 1979, under the joint sponsorship of the Subcommittee on Science, Research and Technology (House Committee on Science and Technology), the Subcommittee on the Handicapped (Senate Committee on Labor and Human Resources), and the Congressional Research Service. Subsequently, a "Joint Report" was issued, having been prepared for the subcommittees by the Science Policy Research Division of the Congressional Research Service.[126]

. Issuance by the Subcommittee on Elementary, Secondary, and Vocational Education of the House Committee on Education and Labor of "Needs of Elementary and Secondary Education in the 1980's: A Compendium of Policy Papers" (1980).[127]

---

[126] U.S. Congress. Joint Report. Senate Committee on Labor and Human Resources and the House Committee on Science and Technology. Application of Technology to Handicapped Individuals. Process, Problems, and Progress. Washington. U.S. Govt. Print. Off., 1980. 317 p.

[127] U.S. Congress. House. Committee on Education and Labor. Subcommittee on Elementary, Secondary, and Vocational Education. Needs of Elementary and Secondary Education in the 1980's. Committee Print. 96th Congress. 2nd session. Washington. U.S. Govt. Print. Off., 1980. 693 p.

V. HIGHLIGHTS AND COMMENTARY: HEARING ON INFORMATION AND COMMUNICATIONS TECHNOLOGIES APPROPRIATE IN EDUCATION (INCLUDING H.R. 4326), OCTOBER 1979

With Representative George E. Brown, Jr., Chairman of the House Subcommittee on Science, Research and Technology, presiding, the first hearing on Information Technology in Education was convened in Washington, D.C. on October 9, 1979. The stated objectives of this one-day session were two-fold:

1. To review H.R. 4362 [a bill to create a National Commission to Study the Scientific and Technological Implications of Information Technology in Education] to obtain positions and issues such as:
   - duties of Commission and feasibility of obtainment
   - scope—computers vs. other appropriate information technologies
   - educational level to be addressed
   - membership of Commission
   - need for Commission or feasibility of accomplishing objective by other means, i.e., OTA, OE
   - coverage—training and market needs
2. To review information technologies appropriate for educational application and related issues such as:
   - cost and benefits of alternative methods of education and training
   - mechanisms for increasing private sector commitment
   - limitations to application and efficiency
   - impacts—effectiveness, societal, training, changes in educational system

The selection of witnesses for this initial hearing was designed, in the words of Representative Brown, to "give us a broad overview on the state-of-the-art, including activities of other nations, as well as to address related issues such as cost and benefits of alternative methods of education and training, mechanisms for increasing private sector commitment, and forecast of technological changes." [128] He then underscored the importance of learning more about "the human decision-making process" and how "we must prepare to take optimal educational advantage of new and revolutionary information and communications technologies." Pointing out that certain heralded technologies had "not met projected expectations," the Chairman went on to say:

[128] Information and Communications Technologies in Education.

> Technology has been viewed primarily as a delivery system for education rather than a means of creating a wide range of environments in which the learner can explore new concepts, exchange ideas, and initiate intelligent interaction through multiple pathways.

The criticality of selectively apportioning needed information also was addressed by Representative Brown:

> The innovative application of technology could serve to reduce the gap between the surplus of information in society as a whole and the shortage of desired information available to individuals.

And finally, in regard to the increasingly interactive nature of the several information technologies—typewriters, telephones, videodiscs, radio—he noted that "Such advances will have considerable impact on many of our social and political institutions and hold potential for altering the role of educational institutions."

Dr. Lewis M. Branscomb, Vice President and Chief Scientist of the International Business Machines Corporation, appeared as the initial witness and began by observing that:

> Much of the emphasis in H.R. 4326 is on the pace of technological progress. My own view is that the pacing factors are institutional responses, not technology, and it is in the area of institutional response that the key questions arise. How will educational materials for the new technologies be generated? Will teachers view the computer as helpful or as a threat to their jobs? What are the incentives for educational productivity if indeed these tools contribute to productivity? Can objective measures of students achievement gain enough acceptance to make self-paced education practical?

Dr. Branscomb next talked about the early optimism of the 1960's regarding computer-aided-instruction (CAI) and computer-managed-instruction (CMI) and the ensuing disappointment. Now, he pointed out to the Subcommittee, many "believe that education will yet be transformed by contemporary information technologies, and I am among them." He then said that we must not "lose sight of the role of the technological innovator," and told of early discussions between the Carnegie Foundation for the Advancement of Teaching and Thomas J. Watson, Sr., president of the IBM Corporation, regarding how best to test the product of educational institutions at critical points. A long-term project by the company resulted in an invention by R. B. Johnson which could "instantaneously penetrate a long and difficult examination and * * * correctly record the exact performance of the student." This was many years before the invention of the modern computer as we now know it.

The witness then noted that as rapid changes in education and training for adults become possible, extensive and continual retraining will be required as employers introduce new technology in order to remain competitive while still attempting to sustain a stable employment milieu. The circumstances must be realized:

* * * the teacher is paying the student's salary, not the other way around, and * * * there is an obvious incentive to look for ways to increase educational effectiveness and increase educational productivity.

The IBM Corporation, he said, runs an educational system for its employees involving over 3,000 full and part-time teachers, and offers three million students-days of instruction, largely using computer-assisted or computer-managed instruction. An example of this endeavor is the large Denver computer installation, with a network of 400 terminals, which provides computer aided-courses to 10,000 Field Engineering Division employees of IBM located throughout the country. This network is "an excellent return on investment," Dr. Branscomb emphasized, since "Just the savings from avoiding travel expenses and per diem associated with the more traditional classroom approach exceed the cost of the equipment by a considerable margin." Next, he raised a point which would be echoed in later presentations and discussions:

> If we don't restrict our idea of education to the formal classroom experience in a conventional school environment, then it is clear that the impact of computers and communications is even greater. Education to impart a specific skill or midcareer or even pre- and post-retirement education are potential markets that the private sector may well invest in and pursue. Similarly, do-it-yourself training and recreation or game oriented education for the whole family lend themselves to the new technologies.

After talking briefly about the expectations for public television use in the education field, Dr. Branscomb turned to the roles which new technologies can fulfill. For example, the videodisc when combined with a microprocessor for random access possesses the capability to form the basis for a sophisticated interactive audiovisual teaching system of relatively low cost. Direct broadcast satellites beaming to small home and office antennas are practical, he noted, and media companies are already considering specialized educational programming as a way to use the new channel capability for specialized but dispersed audiences, such as doctors or businessmen. In his formal testimony, Dr. Branscomb alluded to the development of "talking devices"—such as the early "Speak and Spell" unit created by Texas Instruments—and speech recognition equipment as adjuncts to education.

In talking about the underutilization of computers by the educational establishment, Dr. Branscomb admitted that "the costs of today's CAI systems are indeed high, and this works against their adoption by public school systems."

> * * * but time is on the side of technology. The approximate per pupil cost of public education in the United States has been rising at about 10 percent per year over the last 10 years, up to about $2,070 per year, from only $816 ten years ago. But the cost of computer technology has been falling at the rate of about 25 percent per year for the last 20 years. Now, today,

a student could have access to a computer terminal in one of his classes for less than a 10-percent additional educational cost. If we project the costs of both instruction and computers out 10 years, the extrapolation suggests that computer assisted instruction could be made available to all students in all their classes for a similar reasonable price.

An enumeration of the ways in which an institutional structure discourages the incorporation of new technology followed:

- Lack of incentive in educational institutions to improve their productivity.
- Lack of access by schools and colleges to capital for equipment investments [even where such equipment would be cost effective].
- The obvious truth that wisdom and values are the true primary educational objectives, not so suitable for teaching with a computer as would be vocational and structured learning.
- Reluctance of teachers to accept radical changes in their role, and in fairness to the teacher, a mature judgment on their part about the practical problems of maintenance and security for such equipment.
- Lack of market incentive to generate good quality, useful instructional materials.

Special education is one area where Dr. Branscomb felt that technology will be employed increasingly, and among the research projects on-going he cited the work being performed by IBM's Scientific Center in Paris which was designed to help deaf children learn to speak understandably through a combination of lip reading and computer supplied cues.

In considering the "proper role of Government" in this area, Dr. Branscomb noted in his formal testimony that the new Department of Education should have an Assistant Secretary responsible for educational research and technology. Among the steps which he recommended should be taken by government:

1. The Department of Education should take the lead in understanding the institutional factors that have . . . made progress slow. If . . . further research is needed . . . field trials and demonstrations [should] be one in a realistic user environment.
2. The Department of Education should lead an interagency working group to evaluate the effectiveness of all the Government education programs . . . and initiate improvements.
3. The Government should maintain an even hand between private and public educational institutions, being sure that the increasing support going to public channels does not leave the private institutions in an unviable condition.
4. The Congress [should] heed the President's message on telecommunications regulatory reform that he sent up on September 21, 1979, for . . . the innovative capacity of our computer communications community is substantial and it should be fully unleashed.
5. The House Committee on Science and Technology might well examine carefully the adequacies of the Science Foundation's resource requirements for assisting universities with their computer needs.

And finally, in commenting on the specific proposal in H.R. 4326 for a Presidentially appointed national commission to study these matters, he said.

> I am not opposed to such a commission. My personal view though is that it might possibly delay the Department of Education coming to grips on its own with an opportunity that should be high on its agenda, and thus I think it might be desirable to ask the leadership of the new Department, when it is appointed, whether or not they might carry out the work of the commission themselves on an expedited schedule.

As a point of reference, Figure 11 provides an overview organizational chart of the new Department of Education.

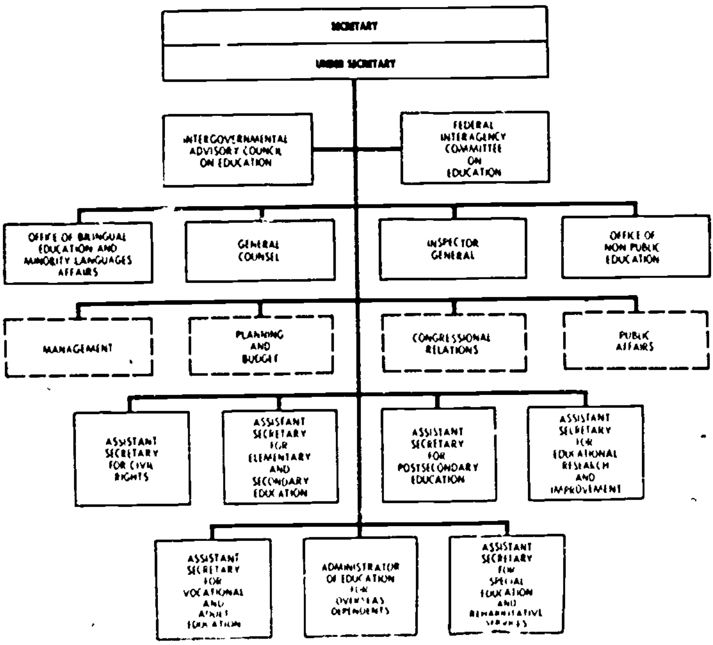


FIGURE 11.—U.S. Department of Education organization chart

In the ensuing dialogue, Representative Brown iterated that the Department of Education had indeed been established after the introduction of H.R. 4326, and that in his opinion "education has broken out of the confines of the classroom." He drew an analogy to the health field, where rapidly escalating costs have caused a tendency "to isolate health within the confines of the hospitals." In commenting upon the effect of such "reductionism," Dr. Branscomb indicated that "a lot of innovations might arise outside of the school institutional structure."

> I would hope that we would not fall into the trap, however, of believing that the problems of the schools can be addressed by accelerating as rapidly as possible the out-of-school developments and allowing the schools to languish in their problems.

In reflecting upon the witness's comments regarding a leadership role for the Government, particularly the Department of Education, the Chairman then asked if Dr. Branscomb was in effect suggesting that the Government constitute a "demonstration market for encouraging the more rapid development of . . . computers and related technologies in education." In affirmation, Dr. Branscomb remarked that "the emphasis I want to give is to challenge the Government agencies to make the most cost effective use of educational technologies."

The next exchange centered on a question raised by Dr. William Wells of the Subcommittee staff, who noted that in earlier hearings the concept of creating "regional demonstration and test centers that require long-term Federal funding" had been raised. Asked for an opinion regarding this "simplistic underwriters laboratory approach to the examination of systems," Dr. Branscomb questioned spending "a great deal of money to measure something that we haven't yet captured." He then went on to say:

> I suspect that educational innovation takes place most effectively in a relatively decentralized environment with specific schools . . . coming to a conviction that they can do something worthwhile and economical.

Reference was made at this point to the pre-1936 interest of Thomas J. Watson, Sr. in the problem of "how do you objectively measure the progress that a student has made?"

Dr. Wells next talked about the type of pragmatic decision which many school districts must face when told of such diverse systems as PLATO with its central processor and multiple terminals versus one featuring a microstandard processor. How is the decision made, and can it be made in-house or should outside consultants be used? Oftentimes such "very, very sophisticated decisions . . . go far beyond the technology." Dr. Branscomb's response was that traditional institutional sources—a State university system—should be tapped. The difficulty of upgrading educational technology then was cited by Dr. Wells, who told of lobbyist pressures which removed encouragement of "greater use of information technologies, more advanced, going beyond the conventional textbooks" from the statement of HEW Secretary Joseph Califano during consideration of the Elementary and Secondary Education Act. This made him skeptical about "relying solely on the Department of Education" for initiatives in this area.

Representative Brown shifted to a related area of concern, the setting up of some "national systems for more effective communication or movement of data around the country," including the regulatory and ownership aspects within the business community. Expressing concern that Congress was not very successful in "modifying the existing statutory base for regulation of communications," he asked:

> Is there a way that we can give direction to this process? Is there some way we can create new institutions or new leadership that will help us move beyond the chaos that we seem to be in now to an orderly system of technological growth and institutional regulation or deregulation?

In response, the witness said that the recent President's message on regulatory reform in telecommunications "is the best vehicle for encouraging experimental institutions." Innovations will be paid for in large part by risk private money rather than public funds. He then averred that "Every trend I see about our life in the future is going to make continuing education a more and more urgent matter," and that those responsible for special education can derive much useful support from the use of computer technology, which may represent the only source "that allows them to effectively tap into our knowledge base and our educational process."

The second witness was Dr. Delbert D. Smith, Attorney at Law and the author of several books on telecommunications and satellite teleservices. The thrust of his remarks dealt with "the application of satellites and space segments to information technologies as they apply to education." Speaking in terms of a "technological imperative," he raised the question of:

> * * * whether or not the educational community will be able to respond in time and in substance with a solution that will make full use of the technology that is being presented to us almost daily.

Dr. Smith then discussed the concept of "multiple pathways"—creating a wide range of environments in which "the learner could explore new concepts, exchange ideas and initiate intelligent interaction." As Director of the Educational Satellite Center at the University of Wisconsin, he had participated in a number of NASA-funded experiments with Alaska, California, and the National Library of Medicine, but had found that "the educational community was very reticent about the new technology." In spite of a decade of experimentation—ranging from the upgrading of teacher skills to servicing remote communities via satellite services—the witness felt that this experience has been largely ignored, but that interest might be rekindled through the present emphasis on the development of advanced information systems in schools and homes.

While noting the plans of such corporations as Comsat General for direct satellite broadcasting systems and the availability of large numbers of transponders. Dr. Smith stated that in the coming years it may be necessary to present the capabilities found in space and computer technologies to the educational community "in such a way that their needs and substantive program plans can be accomplished."

> This runs somewhat counter to the idea of maintaining a level of computer expertise within the educational community and instead says that the concept of education, the goal of education towards universal excellence, and continuing education is important in its own right.

Whereas there have been many discussions about telecommunications parity, with most centered on the revision of the Communications Act of 1934, the witness felt that this concept can be expanded to include such parity for educational purposes and "equal access for all citizens to educational systems, no matter what their circumstances and no matter where their location." He then offered a plan for developing an entire system of educational teleservices:

> An extensive program of research and development in the content of educational teleservices is needed.

The space segment transponder availability issued should be watched closely "so that the people involved in educational development can understand what the technology has to offer in terms of transponder capacity."

Extensive research and development in home and school information consoles that can provide facsimile transmission is a priority requirement.

Turning to the focal legislation, Dr. Smith had several suggestions and comments:

1. "Encourage the utilization of information systems at all levels of education, with emphasis on space teleservice systems and computer technology."

2. The study calling for "a technological forecast of information systems from 1981 to 2000 with regard to educational applications is a good one and is necessary."

3. The study that deals with "sources of financial support, including school financing and local taxation, should be looked at in some depth," for such basic information is needed.

4. The study focusing on R & D to create school and home information consoles is important.

5. The Commission should consider a broader range of institutional studies which look at the implications of imposing information transfer and educational systems on such entities. The potential for joint ventures in research, development, and demonstration programs between NASA and the private sector, as has been done in other nations (e.g., Canada, Japan), is present.

Thus, the proposed Commission could "look at practical demonstration programs that might promote the development of educational delivery systems that would benefit the United States during the 1980's and beyond."

In thanking the witness, Representative Brown mentioned that the usual congressional approach to such a broad area results in several legislative actions "which need to be integrated in some fashion." Next, he noted that private enterprise initiatives such as that by the Satellite Business Corporation—which hopes to create a massive satellite link computer transmission capability—usually are targeted to the major corporations. Dr. Smith, in responding, suggested that while public service satellite consortiums are useful, they do not provide the complete answer:

> * * * because it is not only a question of aggregating known and perceived needs, but assuming the development of technologies over the next decades it becomes an educational function.

Funding options must include, he said, subsidies (perhaps from the Department of Education) or "cost reductions in the utilization of the complete systems" or "cooperative funding . . . from a number of levels of the educational community."

He talked next about the public service satellite consortium, a mechanism raised by the Chairman, which had been established by NASA and HEW "to aggregate communications satellite educational and other public service users," and which was somewhat different from the Corporation for Public Broadcasting and the Public Broadcasting System. Returning to the achievements in other countries, the witness explained that Canada's direct satellite broadcasting program will use their ANIK-B satellite to transmit programs, including those of an educational nature, to 120 participants. Representative Brown, in response, expressed a "sense that we are groping for institutional arrangements within which to develop these technologies" and that the U.S. may lose "global markets to countries that are less developed but better able to focus on the applications of these technologies." Dr. Smith, in agreement, said that:

> Several weeks ago in testimony that I gave in this very room, I pointed out that we have not been able to adequately consider the questions of under what terms and conditions a space station would be built, how users would gain access to the station, what the costs would be, and what the tariffs would be.

With Representative Wes Watkins serving as temporary chairman, Dr. Wells asked whether the contrasting educational systems in England, France, and Japan affect the move toward acceptance of technology in education. The witness replied in the negative, saying again that "at the present time, the United States has so many different legislative initiatives that it is difficult to concentrate on developing operational systems." A case in point: the concern expressed during the Communications Act rewrite for rural communications systems. Dr. Grace Ostenso of the Subcommittee staff then introduced the consideration of how communications satellites affect education and cultural exchange activities in developing countries. Dr. Smith noted a "direct parallel" between the needs of rural America and developing countries, and went on to cite experience gained during the India experiment and the content of the proposal made in Geneva for a global domestic satellite system (GLODOM). At the 1978 UNESCO meeting, he informed the Subcommittee, the United States suggested that $25 million be put toward the utilization of a "communication satellite system for development."

"Are you suggesting then that the scope and mission of the Commission as it is now laid out in the bill ought to be broadened to look at international educational and cultural exchanges as well as the domestic?" was Dr. Ostenso's query. Following his affirmative reply, Dr. Smith commented that a Commission with a "short-term mandate" might provide responses to immediate problems not possible elsewhere, and that a one-year time frame for its existence would be "adequate."

The final dialogue involving this witness was with Dr. John Holmfeld of the staff who focused on the element of acceptance (or nonacceptance) of computer technology by the educational community. While admitting that "I personally have no desire to ever communicate with a computer or learn how to do it," Dr. Smith said that he "would not be averse to utilizing the technology in a transparent way to increase the effect of what it is I was trying to communicate to my students." Dr. Holmfeld then posed this question:

Do you hope that a Commission such as this could come forward. not simply restating the conclusion of what you call the decade of experimentation, but with something new and imaginative which could in a sense be the Sputnik of this field, maybe?

The answer by the witness stressed the importance of developing "comprehensive demonstration programs that would involve not only a space segment but advanced computer technology." This would be combined and demonstrated in an educational context at various levels of the educational system and in various geographic regions.

Appearing as the third witness before the Subcommittee was Robert G. Gillespie, Vice Provost for Computing at the University of Washington. Noting that he had very recently been involved in an NSF-supp .ted study of the demands and needs in higher education for computing, Mr. Gillespie commenced by making three points:

* * * the Nation is at a certain level of development in computing and higher education because of some very shrewd decisions the last 10 or 15 years in resource investments.

* * * other countries have more strongly recognized different aspects of computing and the computer revolution so that they are able to lay groundwork for some long-term strategies that will affect our leadership role.

* * * the Commission proposal may be a good vehicle for touching on some of the major issues. Specifically, it can take up the issues concerned with transition—that is, how do we get from what we are doing today to a place where we can use some of these new technologies—and the area of limiting factors.

He then pointed out that a recent study [129] by John Hamblen estimated that higher education expenditures for computing total about $1 billion, and expressed his concern that such support "has increased most rapidly not in instruction, not in research, but in administration." In commenting on past investments in computing, Mr. Gillespie cited two key NSF programs, the first of which (in the 1960's) was designed to "accelerate the Nation's capabilities in computing and technology through a program for matching in order to stimulate people to acquire computer systems." By the end of that decade, one-third of the universities had computer facilities. The second program, in the late 1960's, focused on network development, with an accompanying "large jump" in user access. The witness estimated that at the current time, "nine-tenths of the students in higher education have access to computer facilities." Others appearing before the Subcommittee would disagree.

In illustration, he stated that the University of Washington with 36,000 students would have to multiply its investments in academic computing by a factor of 4 or 5 to achieve the kind of access available to students at Rensselaer. And this, in spite of already spending $2 million out of a $400 million a year budget. He went on to remind his listeners that "the glamour of the technology and the excitement about

[129] Hamblen, John W. and Thomas B. Baird. Fourth Inventory of Computers in Higher Education 1976–77. Princeton, EDUCOM, 1979. (Various pagings.)

the drop in cost" does not take into account other cost factors: people to support the facilities and training, to mention only two.

Turning his attention to efforts in other countries, Mr. Gillespie mentioned the Japanese report which aimed at the "informationalization" of society, the English initiatives to create microprocessing laboratories in many universities, and the French program which would place perhaps as many as 10,000 microprocessors in their high schools. In our country, it is now possible to purchase a computer for less than $1,000, which results, the witness explained, in many students arriving at the university level with a background in programming. There is a concomitant drawback, in that "their expectation for computing access is at a peak," and university resources are often hard pressed to meet such demands. He then cited the difficulties at his university in providing "specialized computer services in fields such as engineering."

In reference to the work of the projected Commission, Mr. Gillespie had two recommendations:

> * * * that the commission scope be pointed to identifying some of the requirements that we need to meet over the next few years, particularly to insure that we take up some of the issues that inhibit the penetration of computing.
>
> * * * that a 1-year life is extremely short for the broad issues that the commission may well be directed to look at, and that a 2-year life would be reasonable.

Upon the completion of his oral testimony, Mr. Gillespie was asked by Representative Watkins: "Is the commission established to help develop both national goals and programs to maintain our momentum?" to which he replied that "I would like to see that we articulate the objective that all students would have experience with computing as part of their educational development." He next talked about the difficulty in obtaining funding to procure modern equipment, since in many universities teaching tools are often many years out of date. At this juncture, Representative Watkins remarked that:

> You speak of networks and, of course, higher education has taken the lead in innovation in many areas and could probably have also in the overall computer program. You know we don't even have a network set up on a Federal system where we can get information from our labs to a centralized spot or to an area that computer services from the higher education could reach.

Mr. Gillespie observed that there are technical and management problems associated with networks which "are holding us back." He pointed out that many campus computing centers are operated like a business establishment, with administrative inhibitions on transfering dollars back and forth.

In response to Dr. Ostenso's question about problems associated with "courseware," the witness noted that "the investment of faculty time is critical" to such development. The University of Washington, he said, makes heavy use of computers as supplements to courses, and "the lowering cost of microprocessors means that we can use [them] . . . for drill and practice areas within the instructional program."

An example: for beginning chemistry students involved in scientific notation, a microprocessor can be useful; or, its utilization in simulation activities such as chemical experiments. Dr. Holmfeld asked:

> I sense that when you prescribe the kind of computer training you give the students, you are talking about teaching them how to use computers for their own purposes, how to design things, how to make it calculate. The kind of computer use that has been described to us earlier by Dr. Smith and Dr. Branscomb is a much more passive use; that is, making the computer substitute for the teacher.

In his reply as to whether this was a valid distinction, Mr. Gillespie said that their penetration was of each kind:

> • We use and teach about the computer as an object of study.
>
> • We use the computer to teach people to use it as a tool.
>
> • * * * we teach them how to program and use it in engineering, but the one we focused on in educational uses is a tool to improve the quality of teaching.

When asked if there had been an instance when computer assistance had been phased out, Mr. Gillespie told of using the computer as an aid in a computer-based educational experiment in large classes in economics where a "weekly testing and diagnostic program was developed." This process caused the instructor to reshape the course, which presaged a problem if that teacher should later leave the institution. The next series of questions came from an AAAS Fellow on assignment to the Subcommittee, Dr. Michael Breton, who inquired about the problem of State versus private financing. Mr. Gillespie explained that "the financing of higher education [in] a large university is fairly complex" and that there might be difficulty in enunciating clearly the importance of computers. He continued:

> * * * within some institutions, the importance of computing as contributing to the student is more easily recognized in either a smaller institution or an institution that has much deeper control over its own resource allocation.

In the State schools, he iterated, there was a real problem in reallocating available funds. As to whether private sector schools are in "particular jeopardy," Mr. Gillespie felt that smaller schools can move to meet student needs with small facilities whereas the investment required to service a campus of 30,000–40,000 students is often beyond reach.

Dr. Stephen Ziman, another AAAS Fellow, returned to the subject of "regional resource centers" and the pooling of funds:

> What have you done in terms of industrial-university relations when such facilities are available, both as a teaching mechanism and as a research mechanism?

Mr. Gillespie then told of how the Boeing Company, which had been using the University of Washington low-speed wind tunnel, an aging facility, chose to donate a computing system—both hardware and software—because this could be done less expensively than building its own private facility. He also mentioned that the University is trying to determine some way to have access to the three Boeing large-scale computer systems, particularly for use by graduate students.

Representative Brown, after describing a "cross-continental teleconference" in which he had participated and a visit to an elementary school cable network, asked Mr. Gillespie:

> Do you have any such facility at the university level or do you see a need for this kind of networking capability for purposes of teleconferencing, sharing data, sharing research results, engaging in other forms of information transfer?

The witness responded that there had been one "very successful utilization" in the medical area under the Washington-Alaska-Montana-Idaho program, whose "primary objectives were to broaden the base of medical students across a number of States . . . and perhaps encourage more students to remain in the States that they were involved with." As to whether satellite communications were used in an "operating theater," Mr. Gillespie indicated that they were more probably employed in the diagnostic process:

> * * * [resulting] in making available to someone in Alaska being examined * * * access to a broad number of specialists rather than require them to be sent to the location of specialists.

It came down to a matter of trade-offs: "The problem is finding those that are 10 times better than some other choice, not just that it's better." With this exchange, the morning session of the hearing was concluded.

Two representatives from the senior staff of the National Science Foundation were the first witnesses before the Subcommittee during the afternoon session on October 9: Dr. F. James Rutherford, Assistant Director for Science Education, accompanied by Dr. Andrew R. Molnar, Program Manager for Research and Science Education.

Dr. Rutherford commenced his testimony by encapsulating a series of comments regarding the efficacy of the proposed commission. He noted that:

> * * * the National Science Foundation and other agencies who care about this are doing the kinds of things, although perhaps not quite at the appropriate level, that a commission would instruct them to do.

Specifically, he addressed the question of leadership, observing that there are people—such as Dr. Richard Atkinson and senior NSF staffers Molnar, Deringer, and Lipson—already in place "who understand the nature of learning technologies and how they might be used." A commission would ask agencies to make projections, and Dr. Rutherford pointed out that this was being done, citing a recent NSF report entitled "Technology in Science Education, the Next 10 Years—Perspectives and Recommendations." [130] He went on to predict that agen-

[130] U.S. National Science Foundation. Directorate for Science Education. Technology in Science Education. The Next Ten Years—Perspectives and Recommendations. Washington. National Science Foundation. 1979. 57 p.

cies would be urged to invest heavily in "R & D related to the application of technologies to the learning process," which was already part of the NSF program designed to lead to:

> * * * a deeper understanding of the process of utilizing technologies to learn, and also the development of appropriate instructional materials using computers, video-discs and the like.

Another activity area of potential commission concern where NSF is active involves faculty training. Dr. Rutherford told of "short-term programs for both college and pre-college faculties to help them understand how these devices can be used in their work." Next, "We would be instructed, I believe, to be versatile enough and informed enough to take advantage of what is on the horizon, special opportunities," and here the witness talked about NSF's efforts with regard to the "so-called intelligent videodiscs." And finally, in the matter of coordination, he noted that Dr. Atkinson was serving as leader of bimonthly meetings involving people from more than half a dozen major agencies that "meet and compare notes, share information, and try to coordinate." These several facets of on-going activity could be seen as an "argument against the need for a Presidential commission."

Dr. Rutherford then enumerated significant considerations on the other side of the question, including:

- the matter of "visibility," which is currently lacking: "it isn't known what the agencies are currently doing . . . A Presidential commission can bring visibility and it can bring the need to the attention of the people actually that make decisions."
- the fact that "a commission can bring top people to the task . . . The best people in the land really must serve if the President asks them."
- the potential which a commission has for going "beyond the Federal perspective," since an individual agency's point of view may be necessarily restricted in scope.

Assuming the establishing of such a commission, the witness underscored the importance of spelling out the exact tasks which it would be charged to fulfill. "They need to be manageable tasks . . . ones that we need help and information on, so that a final report . . . will bear on the appropriate matter."

The second portion of Dr. Rutherford's testimony was focused on the various kinds of tasks which the proposed commission might undertake, with six of these being delineated:

> 1. Making projections of probable trends in information technology and their implications for education that are different from those that a Government agency can make by way of its own resources . . . These projections can be both shorter and longer range . . . [since the] commission . . . not having the constraint to work through next year's budget or the 1981 or 1982 budget, can in fact take a broader or more distant view of where these technologies are heading.
>
> 2. Make recommendations for action, action in the here and now on what information technology should be used in schools and college and for what purposes . . . they may want to

pay . . . particular attention to . . . the pre-college level . . . [A] commission might come up with steps that would say how do you bring about the implementation of what we already know we can do, but are not doing in our schools, elementary and secondary.

3. List actions for Federal agencies that would address the question of the public understanding of these technologies . . . the American school system ought to help them understand the strengths and uses and weaknesses of these devices.

4. Identification of the elements of coordinated Government action that are needed to encourage the participation of the commercial and industrial sector . . . individuals need to be inventive and American industry and the publishing industry among others, have to work on the problem. This means getting into the making of recommendations on such matters as patent and copyright law, standardization regulations, Government procurement policy, and tax incentives.

5. Alert the public and educational community to the potential unforeseen consequences of the widespread use of such devices . . . there are consequences, side effects, that were not projected or predicted and which many people regard as being negative if not harmful.

6. Clarify the ways that educational use of the new technology can contribute to progress in our national productivity, development of appropriate technologies, and technology transfer . . . we not only want the technologies to be used for learning purposes but to be understood and used in ways which contribute to these national needs or goals.

Following the conclusion of Dr. Rutherford's testimony, Representative Brown recalled Daniel Bell's perception [131] of our post-industrial (or information) society, which included an emphasis on the integration of various technologies—computers, televisions, satellites, fibre optics, among others. He and the witness exchanged ideas regarding this trend, with the latter agreeing on its importance and noting that the NSF through its research funding attempts to strengthen this approach. The chairman then referred to "a real problem situation," stemming from our seeming inability to create a "structured program or plan of action aimed at coordinating our efforts in this area." Representative Brown next pointed out that other nations (Japan, England, France) had faced up to some of the critical information problems, and asked if the United States has "a lack of coordinating ability to do strategic planning . . . to bring together various segments that are involved in . . . analyzing global markets and developing a role of U.S. technology in them?" Dr. Rutherford acknowledged that some of our planning efforts are not as "centralized" as those elsewhere, but opined that "the long term strength of our system is its diversity:"

We have industry working and competing, and we have different agencies sometimes competing with each other, often

[131] Information and Communications Technologies in Education, p. 93.

77-352 O - 81 - 9

> to the good . . . What we have to do is have enough discussion at a high enough level so that if things get badly out of synchronization where we are working at odds with each other we can try to find out what the trouble is.

Representative Brown then voiced the hope that this country can "come up with a coordinated program . . . that will encourage private enterprise to take the appropriate action," and asked if the NSF was not doing many of these very things? The reply was that the Foundation is "trying to analyze, to look at the entire picture," followed by Dr. Andrew Molnar's statement that the NSF budget for the technology component was in the $7–10 million range. Dr. Rutherford added that with funding limitations, coordination with other agencies is a consideration:

> * * * the National Institute of Education and ourselves are embarking . . . on a cooperative 5-year plan to look at the use of learning technologies, principally computers, in mathematics at the pre-college level.

An exchange of questions, answers, and clarifying comments then ensued between Representative Donald J. Pease and the two witnesses, centering on the Subcommittee member's interest in the H.R. 4326 provision dealing with the preparation of forecasts concerning the effects of increased use of computers in education and school financing and local taxation during the period from 1981 to the year 2000. In particular, he was concerned with:

> * * * the degree to which [computers] . . . have been or are being used now by decisionmakers for decisions about school finance and local taxation which affect schools broadly, not individual schools.

The final discussion involving Dr. Rutherford emphasized NSF's role in science education, which according to the empowering act was to "foster and support the development and use of computer and other scientific methods in technology primarily for research and education in the sciences." This mandate had not yet been affected by any actions within the new Department of Education, but Dr. Rutherford expressed his intent to "take the initiative and try and bring that about." He saw no problem regarding NSF's present programs because within the Science Education Directorate "our concerns are very applied . . . Our mandate is to improve science instruction and science understanding in the country."

The next witness was Dr. Judith B. Edwards, Director of the Computer Technology Program, Northwest Regional Educational Laboratory in Portland. Announcing that her testimony would focus on statewide efforts in using computer technology in the States of Oregon and Alaska, Dr. Edwards commenced by describing the Oregon experience which began in the middle 1960's. A converted bread truck with a computer inside was driven to rural, isolated communities' schools in order "to provide computer literacy, to do teacher training, and to provide some experience for the teachers and students on how they could use a computer to enhance learning." Several obstacles were encountered during the course of this Title III project of the Elementary and Secondary Education Act:

> * * * there was an immediate and urgent and continuing need for teacher training . . . [and] an unwillingness on the part of the existing institutions . . . to systematically provide that teacher training.
>
> There was a lack of adequate instructional software and materials related to computers. The hardware was available.
>
> We had three different kinds of computers . . . None of those computers was compatible with each other in any way. The software was not compatible.
>
> There was also lack of evaluation data on the CAI theories, methods, effectiveness, and costs.

When the project funding ran out, the computers were placed permanently in the schools and are still in use. A long-term NSF grant for the Oregon Council on Computer Education did allow teacher training and materials development to continue, and a publication called "Oregon Computer Teacher" still is published, with nationwide subscription support.

The witness then provided a few key statistics on computer costs—comparable computing power available now costs one-tenth of 1960 expenditures—and school use of computers. Data derived at the Northwest Regional Educational Laboratory for a six State area—Alaska, Hawaii, Washington, Oregon, Montana, and Idaho—indicated this school use of computers for instruction:

[In percent]

	1979	1982
State of Oregon school districts	54	71
6-state regional area school districts	34	58

Note. By 1982, it is anticipated that the 6 Northwestern States will have 96 percent of their school districts using computers for instruction or administration.

Dr. Edwards then turned to a more recent experience, in Alaska, supported with matching funds from the National Institute of Education and the State legislature. This project, beginning its third year of operation, is illustrative of the versatility of advanced technologies and those who strive to employ them. Excerpts from Dr. Edward's testimony reveal a spectrum of uses:

> In an Eskimo villiage 200 miles above the Arctic Circle in Alaska, two teachers supervise the education of 23 elementary and 5 high school students. The temperature outside is −32° . . . On the roof of the small frame schoolhouse . . . is a "dish" that receives signals from RCA's Satcom satellite. Inside, while the lone high school teacher gives a lesson in consumer mathematics to four of the students, the fifth sits at a space age computer terminal, watching a screen.
>
> A school superintendent in Adak, an island 650 miles west of the tip of the Alaska Peninsula, receives a message at the computer terminal that an important workshop will be held in Anchorage on teaching language skills to hard-of-hearing primary children. By the end of the day the superintendent

has made arrangements for travel and notified the workshop sponsor, by a computer message, that two teachers will attend.

In an Athabascan Indian village on the Yukon River, a committee of parents and teachers has been working on improving the curriculum. It has identified social studies in grades 4 to 6 as a problem area, because the conventional texts and materials have little relevance to village children. They need resources . . . So a trained operator in their school offices searches stored information in the memory of the computer in Juneau [950 miles away], available through a telephone call. One by one, abstracts appear on the screen, and those that look promising are printed on the attached printer.

The witness then stressed that combinations of telecommunications, microcomputers, and sometimes radio were required in order to provide the services "desperately needed in bush areas." Pilot testing of two courses on English and Alaska history to be delivered in the fall of 1979 were mentioned, as was the "heavy involvement on the part of Alaska educators and users in the selection of the courses, goal establishment, review and testing." Dr. Edwards, after noting that "packet-switched networking such as Telenet is bringing telecommunications costs down to more affordable levels," concurred with Dr. Smith's earlier remarks that we "must find new and innovative ways to use telecommunications other than just presenting a talking head on a television screen." Returning to her earlier testimony, she stated that most of the obstacles which were present in the Oregon computer instruction network project 15 years ago exist now; in particular she talked about:

> * * * an urgent and continuing need to train teachers and administrators.
>
> The need for adequate instructional software and materials certainly still exists * * * There are a few successful and expensive, for the most part, CAI systems available such as the PLATO system.
>
> [She then referred to a catalog called "Robert Elliott Purser's Reference List of TRS-80, PET and Apple II Computer Cassettes" which, while featuring comprehensive listings for these three popular microcomputers, offers the caveat that "95% of all the programs listed in this magazine should never have been offered for sale."]
>
> Standardization is still most urgently needed . . . Although the common use of program languages such as BASIC and PASCAL has allowed some limited transportability of software, every machine uses its own dialect of BASIC requiring adaptation.
>
> The development of CAI lessons and courses is by far the most expensive and time-consuming element of the hardware-software-courseware package. Thus, wide dissemination depends on schools being able to share materials developed elsewhere without massive modification.

Citing an "unprecedented increase in the need for information, support and technical assistance on the part of teachers and administrators," Dr. Edwards described a current project under the aegis of the Northwest Regional Educational Laboratory to design and plan a CAI clearinghouse at the precollege level with NIE support.

In closing, the witness stated that "computers will be used in schools, whether or not there has been adequate research on the psychological and social consequences, and whether or not CAI materials of high quality and humanity are available." She again touched on the dramatic decrease in hardware costs and the continuing high cost of personnel and materials. Her second point dealt with the CAI software availability problem, for which she had three suggestions:

> 1. Funds for research and development are needed to stimulate and support new work and to build a pool of available materials.
>
> 2. * * * Funds for widespread dissemination of demonstrated successful CAI are needed as well as for research into models for effective dissemination of appropriate technology.
>
> 3. * * * standardization of hardware and programing languages at the Federal level if widespread sharing of materials is ever to be realized [is needed].

And finally, the witness urged that attention be given to "providing practitioners and users in schools with the advice, information and technical assistance they need to effectively implement the use of computer technology in improving education," which might be accomplished through "centers of excellence where advanced R & D can be carried out."

A brief exchange ensued between Representative Brown and Dr. Edwards, during which it was stated by the latter that she would recommend "a continued substantial role for the NSF in providing funds and some effort at bringing about coordinated policies" within this area. Dr. Ostenso then raised the question of "evaluation strategies," asking:

> Does this type of evaluation have the same problem as determining quality materials for dissemination, that is evaluation models or criteria must first be established for determining what constitutes effective or quality materials? Are there some validation techniques that have been used in education programs that might be applied?

Noting that more sophisticated techniques are needed than are now generally available, Dr. Edwards emphasized that "There has not been a lot of attention paid yet in how to evaluate the effectiveness of CAI simulations." Dr. Holmfeld then recalled having seen the PLATO system demonstrated on Capitol Hill eight years ago,[132] and asked why it had not seen wide application. The reply focused on the system's costs which were judged to be "prohibitive" for the Alaskan project.

Asked by the Chairman about computer versus transmission costs, Dr. Edwards told him the PLATO system had cost $2 million the first year, and $1 million per year thereafter, "the majority of which was communications costs." Cost considerations have not kept a few private firms from taking initiatives in the educational technology area,

[132] Information and Communications Technologies in Education, p. 117.

she commented in response to a question from Dr. Holmfeld; in fact, the Apple Computer Company has "established a foundation which is providing equipment for schools, so that they can develop software." Dr. Holmfeld subsequently talked about the Subcommittee's review of an NSF curriculum which utilized filmstrips, movies, and projections—costing about $2,000—and asked for a comparison of this capability with various CAI resources. Dr. Edwards replied that:

> It's a literacy difference, and I don't know if it's a qualitative difference. The man on the street, the teacher in a classroom, can deal with filmstrips. They took audio-visual aids as preservice training, and they know how to handle a film projector, but they don't know how to deal with a computer because they did not take a course called," The Computer as an Instructional Tool."

The discussion then turned to the quality of teaching talent, with Dr. Breton asking whether there is "a need to attract more talented teachers and could the sophisticated use of computers be used as an incentive" to that end? The witness agreed that "not every teacher can be a good developer of instructional materials" and went on to say that the computer "will bring some talented and creative people back into the teaching profession." In response to Dr. Ziman's suggestion that standardization of equipment might be effected through State level initiatives, Dr. Edwards said that some had tried; e.g., the Minnesota Educational Computing Consortium issued a competitive bid which was won by the Apple microcomputer, but some schools still are purchasing other units. "There is no mandate saying they can only buy the computer the State has recommended."

Dr. Robert Hornik, associate professor at the Annenberg School of Communications at the University of Pennsylvania, was then welcomed by the Subcommittee as the next witness. Stressing at the outset of his testimony that his primary concern "has been with more conventional technologies . . . like radio and television and their application to the information and education problems of less developed countries," the witness pointed out that in development programs, communication can extend beyond "the message-carrying function that is their technological character." He pointed out that the role of communication technology may be to "replace a voice of inadequate quality, or be the voice where none exists."

After mentioning an experimental program, supported by AID, of daily agricultural radio broadcasts begun in 1973 in Guatemala as an example of the former role, he then discussed at greater length a project in El Salvador (in the late 1960's) where instructional television would "provide the voice of the master teacher in the classrooms at the seventh through ninth grade level. This AID-supported endeavor resulted in the quadrupling of enrollment in those grades within ten years. It should be noted that the winning candidate for the presidency of that nation had chosen educational reform as a major campaign issue. Such endorsement often adds charisma to such a social or educational service initiative. Also, the very nature of sophisticated information technology can result in it being viewed as having a "potentially sexy innovation in education."

Dr. Hornik then cautioned that:

> An innovation in an educational process can be excellently conceived, and successful in affecting learning outcomes in its early use, yet, over the long haul, fail to maintain that success. Teacher retraining as a route to improved classroom instruction may suffer this fate.

The burden of "maintaining the changed environment," as in the AID-sponsored Radio Mathematics experiment in Nicaragua. can be lessened for the teaching cadre:

> Once the curriculum was complete, although modifiable, it represented a substantial obstacle against backsliding. It [the 30-minute radio broadcast] was there, every day, in the classroom, structuring the mathematics instruction.

Thus, the witness explained, such technology when applied directly "can provide a backbone to both organize and maintain change in a resistant environment."

Another critical factor was detailed by Dr. Hornik, as he shifted his focus to more sophisticated information technologies:

> On the one hand if the technology is accompanied by good software, there is no great worry about distortions in the implementation of the curriculum over time as with teacher-dependent innovations. On the other hand, the individualized character of much of the proposed use of Computer Assisted Instruction and other applications of the new technologies, works against the maintenance of the pace of the group which is an advantage typical of broadcast technologies. There is the risk that the sense of a community of learners, reinforced in their own efforts as they move through it all with others, may be lost.

Noting that in developing countries the more affluent communities receive the better teacher, textbooks, and facilities, Dr. Hornik pointed out that communication media can provide "universal access." He then observed that "the inequalities in resource allocation are less extreme in the U.S.," as compared to many developing countries. Also, financing issues will be in the forefront as scarce resources cause government authorities, expecially at the local level, to make choices. Hardware purchase and maintenance and the acquisition of costly software will be problems, even if Federal money becomes available. Next. he remarked that some "people assume that soon everyone will have their home information utility," but "Some will have better conditions at home to make use of the machine" than others.

> The potential of the technology is but one influence—the existing school structure will constrain the use; existing economic and social conditions will condition the timing and effectiveness of use. We may be able to design a way around the "natural" inequality of benefit associated with new technology, but the precedents aren't optimistic.

The succeeding portion of Dr. Hornik's testimony was on communication as improver of quality, and he commenced by talking about "distance education." Using the British Open University and the Israeli Everyman's University as examples, he spoke of how correspondence, textbooks, written assignments, television, and radio are combined with some face-to-face instruction; the Dominican Republic's Radio Santa Maria which offers equivalency degrees is another useful example of the use of technology. Dr. Hornik then pointed out how curriculum writers "were forced to think through the learning process at a level of detail that had never been required before;" in other words he said, "They were themselves responsible for defining a complete educational package." A future focus must be on "improved instructional design," as stimulated by the introduction of new information technologies. Reference next was made to the "Radio Mathematics project" in Nicaragua, made possible by the NSF-funded work of Patrick Suppes and Richard Atkinson who developed an innovative CAI-type mathematics curriculum that was later implemented in revised form by Computer Curriculum Corporation.

Dr. Hornik turned to the role which communications technologies can play, and said that the success of a program "depends on what else is done along with the investment in communication technology." The degree of political commitment can be crucial, as in the El Salvador, Niger, and Nicaragua projects, the first of which had strong support but the other two have questionable futures. As regards analogous situations in the United States:

> * * * information technology may be viewed as an outsiders' innovation. Without political commitment behind its implementation at the federal, state, or less feasibly, at the local level, it will not penetrate the naturally resisting barriers of the local school system.

His next topic dealt with software and its creation:

> Without proper incentives there is no reason to believe that private enterprise or the scholarly community will produce adequate software for use with the new technology. The hardware cost may drop precipitously, but there is no reason to believe that software development costs will drop at all . . . where will the incentives be to create innovative software? Will profit be a sufficient motive? Not unless there are federal funds to subsidize research and development . . . All of the major research and development of computer assisted instruction has been substantially underwritten by federal sources.

The witness then reminded his listeners that communication technology "must also serve a genuine need" rather than being imposed by authority without convincing the ultimate users of its value to them. The social context within which such technology is used drew this comment:

> What are the problems we are trying to solve? . . . what is the character of our failures—are they those of poor teaching, or inaccessible resources? If they are, then new information technologies may have promise. If on the other hand they are a function of what the child or adult brings to the educational activity, or the social context in which the activity oc-

curs, or the perceived rewards for successful completion of the activity, perhaps the role for technological fixes is less prominent.

Many aspects of the educational culture probably will change in the years ahead as information technology is further tested and utilized, especially in such areas as adult education (or "lifelong learning"). This, however, requires "extraordinary motivation," said Dr. Hornik, and the problem of access to terminals in the home or other external locations, because of existing inequities, "will lead to an exacerbation of effective information gaps, and not their reduction." One attraction of *existing* adult education classes is the social character of their arrangement, whereby people can meet together.

In his final section of testimony, Dr. Hornik asked "How does one determine just what the actual potential" of communication technology is, and commenced by saying that "short, highly controlled field experiments" should not be relied upon exclusively. "The real question is how the institutions which will house the information technology . . . will fit them into their ongoing operations. How will they be used when everything else is left to vary?" He urged looking for specific consequences:

> We should not be concerned with the role of information technology in all of non-formal education, but the potential role for such a technology in meeting a particular need—for example, in the provision of qualifying skills which might ease the entrance of urban youth to the job market.

In analyzing this, or any such problem, there are three questions, none of them new, said Dr. Hornik, which must be asked:

- How does one create a new learning process which will fit better in achieving skill mastery?
- To what institutions should the program be linked?
- What demands in time and in attention can be made successfully?

And finally, closing that circle of reasoning: "What specific interactions with the machine and with human sources, and under what circumstances are [they] likely to prove worthwhile?" Evaluation, the witness emphasized, must take place in a "number of settings" and should have "no quickly summative character."

> Rather it should describe the social history of the innovation—how it worked and how it was changed in implementation, and what about it had what consequences, and what it looked like five or eight years after it had been adapted and found its place, or failed to find its place in each of the several settings.

In response to Representative Brown's hope that television could help provide lifelong learning, "with the possibility of considerable market economies," the witness said that "It depends what your expectations are . . . no technology will get around the problem that motivation is primary; someone has to have a clear incentive for participating." At this juncture he returned to his concern, based on experience, that disadvantaged societal groups "are not going to stick with" multi-lesson courses. The Chairman and the witness then discussed the SITE program which served 600 Indian villages. The evaluation of this endeavor revealed strength in its administration and use of hardware, but less value in the courseware used. Dr. Hornik pointed out that what the evaluation "said more than anything else was not so much that people learned a lot, but that they participated."

Dr. Ostenso next asked a series of questions regarding the need for long-term evaluation in this area:

> Where do you feel the Federal responsibility ought to be?
> Should it be in education, science, or behavior and understanding of factors influencing learning?
> Should education address objectives as well as to get success?

Citing again the example of urban youth trying to qualify for entry-level jobs in factories, without having the functional skills, Dr. Hornik underscored the importance of understanding the problem "and how one can solve it with the new and old technologies plus anything we can think of . . . try to develop a solution and then evaluate and see how it works over the long run rather than start with the technology." And in answering Dr. Ostenso's final query as to whether federally funded programs should "always include an evaluation function based on objectives," he indicated two types of evaluation, that which is "designed to get an answer in a year and a half [and] forces people to control things they ought not to control" and that which shows "how the whole institution changes."

The concluding segment of this hearing featured a "grass roots panel" comprised of:

Dr. Allen Lefohn, Chairman, Western Information Network on Energy, Helena, Montana.

A. Stanley Corey, Superintendent, Irvine Unified School District, Irvine, California, and Professor Mitsuru Kataoka, Dickson Art Center Video Laboratory, University of California, Los Angeles, California.

Dr. Nellouise Watkins, Director, Computer Center, Bennett College, Greensboro, North Carolina.

Ms. Colleen Cayton, Development Officer, Denver Public Library, Denver, Colorodo.

Edward K. Zimmerman, Deputy Assistant Secretary of Commerce for Communications and Information, and Deputy Administrator of the National Communications and Information Administration, and Mrs. Kathleen Criner, Program Manager, Information Technology Program of NTIA.

The full, formal statements of these participants, plus certain selected papers submitted for the record by them, are found in published hearings documentation.[133]

Mr. Lefohn opened his commentary by stating that he wished to focus on "the transfer of technical information from the data generators to decisionmakers and the general public." In discussing two information systems—one at the state level and one of a regional nature—he stressed that "the identification of the problem" is often overlooked. The first endeavor to be described by the witness involved the Montana Energy Information Transfer System, developed over

[133] Information and Communications Technology in Education, p. 144-250.

1½ years and tying together 50 libraries of the State of Montana interlibrary loan system with the State energy office, the State library in Helena, and the library at the University of Montana in Missoula. Three types of information may be obtained from this system by going to a local library: (1) a general bibliographic item, (2) a general research search, and (3) additional information on energy research projects.

Next, he described the Western Information Network on Energy (WINE), which was formed in 1977 to tie together the energy information groups in the Rocky Mountain Western States. Approximately 19 States and 350 people now belong to this voluntary organization, which Mr. Lefohn referred to as a "people-to-people network" and which is funded by contributions from its membership. He noted that "outreach" mechanisms have been formed within government, as in the cases of the Department of Energy's Energy Extension Service and the Department of Agriculture's Outreach program. All of these efforts are meeting a need, filling a gap.

He pointed out that the American Society for Information Science (ASIS) has created a new Special Interest Group on Energy and Environment Information, which he will chair. Its intent: to "focus on creating seeds for regional information sharing organizations similar to WINE." Mr. Lefohn explained that these are low cost systems; the Montana Information System was funded with $390 from the Governor's office, plus donations of various persons' time.

In concluding his statement, Mr. Lefohn supported the concept of the proposed Commission for three reasons:

> I believe that some form of round table is needed in order to bring together those agencies and those organizations that have an interest in technical information outreach.
>
> I would like to see the Commission focus in on how we can better develop more viable mechanisms for transferring technical information from the data generator to the people that need it at the local, State, and Federal levels.
>
> I would like to see the Commission focus in on how to get the information to the general public—the people who pay our taxes.

Before calling upon the next witness, Representative Brown noted that he "would like to see much greater emphasis placed on the utility" of the networking concepts described.

In introducing his colleague, A. Stanley Corey, Professor Kataoka informed the Subcommittee that:

> During the past several months the Irvine project team has created a plan to develop the ultimate wired community including interactive computer programing and information services, potentially reaching every home, every school, business, and public agency of a planned community currently with a 50,000 population and projected for 200,000 plus by the late 1980's.

Mr. Corey then proceeded to describe the Irvine project which had a philosophical base which implied that "in the application of technology to the problems of education there has been too much big-brain little-brain thinking:"

It is our assumption that all learners have things to contribute to their own learning and to the learning of others and that if we look in the larger context at America's social problems, our concern is not one of failure of education in a technical sense. It is not one of a failure of education in the informational sense. If there is a failure, the failure lies in the ability to produce self-actualizing, thinking young people who believe enough in themselves to look into an area of interest, gather what data they can, reach some decisions about what should happen and then have the courage to act.

He then outlined the conceptual basis from which the Irvine Interactive Video System proceeds, stating that "productive learning and information exchange take place when communication technology provides:

1. Economical, one-to-one interaction among learners and teachers;

2. Accessibility to information resources beyond the physical limits of the school site;

3. Personal control of and responsibiilty for the learning function, influenced by choice of time and access to comparative information resources resulting in true mosaic inputs;

4. Fluid time with a personal rather than a mass or group constraint upon the traditional idea of classes at scheduled times.

The program in the Irvine Unified School District reflected its creators' conviction that "communication technologies need to be responsive to ideal democratic, social processes. A two-way cable television system utilizing inexpensive consumer software was developed during the past five years, with a capability to link 17 of the 21 schools in that district with the public library, city hall, and the University of California at Irvine. Mr. Corey explained that the system is "decentralized," so each school can transmit its own video signal over the two leased channels and thus share its resources with the other schools. The primary function of such a "decentralized democratic communications network," in the witness's opinion, is:

. . . to move away from the traditional one-way programming where the viewer receives passively whatever is on the air. A far more dynamic use of the medium to create an active participatory system where the viewer and the originator communicate in real time, where the viewer has an equal responsibility for the content of the program and where the roles of each participant fluctuate between reception and creation in a fluid, continuous mode of interaction.

Mr. Corey then broadened his discussion of such a system's potential, including its use on a city-wide basis. In this way, the needs of "special populations"—the disabled, the aged, youths with transportation problems, educators, industries, public organizations—could be better served. Simple "access protocols" have been developed which allow users to switch from one school to another by using oral commands. Each site can originate programs, he pointed out, but "no site has the technical capability to eavesdrop on another's without prior acknowledgment."

The testimony next set forth the various ways in which users of this system can utilize its capabilities; an encapsulation of the major uses shows:

> Teachers—use the system for service training, exchanging ideas, offering mini courses, team teaching in basic skills, and role playing in developing values.
>
> Administrators—conduct administrative meetings without leaving their schools, bring in experts, and offer occasional programing to the community to showcase special school programs (e.g., achievement test results are reported to the community and questions are received via telephone).
>
> School psychologists—conduct guidance clinics and answer questions by phone, hold weekly meetings to coordinate continuing programs which are at multiple sites.
>
> Students—use the system to share ideas, projects, special research, hobbies and learning games.

It should be understood, the witness told his listeners, that:

> Students are in complete control of the system from organizing and planning programs, to setting up, operating cameras, microphones, video tapes, channel selectors, and signal modulators.

The technical apparatus, "simple enough to be understood and operated by 8-year-olds," is "extremely durable and maintenance problems are kept to a minimum."

He then described a joint effort, in the spring of 1978, involving the school district and Control Data Corporation to explore potential uses of two-way interactive cable TV and PLATO, the sophisticated computer education system being marketed by CDC. Stating that the computer "adds an entirely new dimension to live two-way dialog," Mr. Corey offered the opinion that "the combination of the two technologies can provide expanded information and education resources not only for the school district but for the residents of the community as well." Plans for the future include "expanding the walls of the classroom into the community via electronics," and within that context efforts are being made to establish a consortium which would involve the school district, a major information supplier, a major newspaper, a major computer organization such as CDC, and the local cable operator. This will be a "profitmaking venture."

After commending to the Subcommittee a sample "Interactive Video Schedule" which appeared in his written testimony, Mr. Corey commented that the Irvine Unified School District often had been refused Federal grant money because "we already had an operating system."

> I am suggesting that if this is to be the reward structure, then such grantsmanship will not greatly facilitate those who exercise initiative and wish to be operational at an early time.

After Representative Brown's comments regarding the "special circumstances" (i.e., a planned community situation, with unique relationships in some instances) and his question regarding the cost of the system, the witness replied that the capitalization came solely from school budgets, at a cost of about $1,600 per school which has now risen to $3,000; approximately $28,000 is invested annually in cable lease and $70,000 in personnel.

The third panelist, Dr. Nellouise Watkins, initially talked about the disturbing drop in both verbal and mathematics SAT scores, noting that "The alarming statistics cut across boundaries of socioeconomic background, race and sex." After alluding to the numerous hours lost (by children) to watching television, she identified for the Subcommittee the three phases through which education in the United States has progressed, as originally defined by Francis Keppel:

> First phase—the development of a system of universal education;
>
> Second phase—the concern for the equality of educational opportunity;
>
> Third phase—the current emphasis on quality in education.

In regard to the latter framework, the witness pointed out that:

> Central to the realization of quality education on a universal basis is the development of individualized instruction that takes into account the great human diversity in cultural background, styles of life, values, goals, motivation, mental abilities, and personality of students.

Limitations on individualized instruction may be overcome in part by the use of computer, which can also be helpful in curriculum management.

Dr. Watkins then related a research undertaking conducted at Bennett College. "We wished to ascertain if use of the drill and tutorial capability of computer administered curriculum materials could meet individual needs without sacrificing course content." Specifically:

> • We sought answers to questions by investigating factors such as SAT scores, time and motivation on the removal of basic skill deficiencies, a systematic presentation of computer managed courses, an optimal division of the time that should be spent between the teacher and the terminal.
>
> • We investigated which units of freshman English, mathematics and reading are most applicable to the repetitive capability of the computer in assisting learnings.
>
> • We investigated the development of curriculum materials by our own facilities.

As a result of work with control and experimental groups, with pre- and post-diagnostic tests administered to each, there was a "significant difference in error reduction using the teacher-technology combination as compared with the traditional approach of teaching English and mathematics." The time proportion of two classrooms for one lab session produced the most effective results, and countered the belief that "advantages of the computer to assist in instruction are dependent upon 1-to-1 correspondence with lectures and experience in the classroom."

One conclusion which may be drawn, Dr. Watkins said, is that CAI "appears to have too many advantages to reject its contribution toward the solution of some of the problems confronting the educational world today." She went on to say that much of the CAI-related research has been with minority groups, but that for "many institutions of higher education this would not represent the majority of students." Educational programs should serve the gifted as well as the disadvantaged, and in the latter instance the individualization of instruction "is no longer an option, but a necessity" for meeting the challenges of our time.

The establishment of a national Commission, the witness said, is "long overdue," and the need for computer-based techniques to assist in the learning process is evident. Better instruction can be effected through the maximum use of computer technology, but in addition:

> Teachers must become computer literate and develop minimum computer skills if our young people will be influenced to achieve these skills.
>
> Special training programs, conferences, "how-to" techniques, assistance in acquiring hardware, emphasis on development of curriculum materials are but a few of the urgencies necessary to keep us the strongest nation we must continue to be in education.

In closing, Dr. Watkins told of NSF funding a regional conference for minority institutions in the mid-Atlantic region "with the goal to teach faculty in those institutions how to develop curriculum materials which can then be used by all of the contributing institutions."

The presentation by the next panelist, Colleen Cayton of the Denver Public Library, commenced with her referral to the recent Arthur D. Little, Inc. report on "Passing the Threshold into the Information Age." Prepared for the National Science Foundation, this study categorizes information activities into three "eras:" discipline-based, mission-based, and problem based. Illustrative of this organizational approach is Figure 12 (below) taken from that study;[134] although

THE THREE INFORMATION CONTEXTS AND ERAS

	Time Scale of Recent Emphasis	Basic Use of Knowledge	Corresponding Information System
Discipline-based	Era I Traditional, from 19th Century and continuing	Study and development of scientific disciplines; strong growth of knowledge motivation	Discipline-based information systems; mainly research libraries and journal complexes
Mission-based	Era II WW II with height in the 1960's and continuing	Big science & technology; emphasis on Missions like: "Build an Atom Bomb"; "Put a Man on the Moon"; strong engineering and application emphasis	Mission-based information systems; large government-operated documentation systems, computer-assisted
Problem-based	Era III Some starts in the late 1960's; growing emphasis in 1970's	Emphasis on solving socio-technical systems problems; examples; providing better housing and transportation; improving quality of life in cities; equalizing job opportunities; preserving the environment; etc.; strong value judgment inputs.	Problem-based information systems (forms are still being determined)

Each Era represents a value system, a context of activities and a set of corresponding goals and objectives (which may be more or less explicitly articulated).

FIGURE 12

[134] Into the Information Age. Arthur D. Little Inc. Chicago, American Library Association, 178. 134 p.

the emphasis is on scientific and technical information, the broader ramifications are apparent.

The witness stressed that "What we have now is a tremendous need for era 3, because we are already in it and we don't have . . . a problem-solving information system."

Observing that public library personnel seldom have an opportunity to appear before congressional committees, Ms. Cayton stressed the point that "the public library represents a natural resource which is tremendously underestimated, underutilized and certainly underdeveloped." She went on to say that:

> * * * the failure to nurture this institution [has] contributed to the problems that you are focusing on here, the people's unmet needs for information. The pressure we are feeling for that information simply can't be overlooked much longer.

Stating that "the public library is one of those logical places to solve these information problems," Ms. Cayton reminded the Subcommittee:

> We already exist. We have the facilities, we have basic resources, we have manpower. Perhaps we need additional training . . . but I think we are working on that.

Turning to evidence of a new awareness on the part of the library community toward such matters, she referred to the issuance of an entire issue of the "Library Journal" [135] which focuses on information-related issues, an then talked about the forthcoming White House Conference on Library and Information Services.[136]

As regards the bill proposing a national Commission, she expressed disappointment that "the bill does not mention the public library, the only institution in our society that is designed to serve the education and information needs of the public." Admitting that "we are feeling the effects of information technology . . . and of a public that needs to know how to use it," the panelist then told her listeners that:

> It is our responsibility to help in that educative effort . . . to use every technology available to us to make sure that people can get their hands on what they need to know when they need it.

After mentioning several uses of computers by the Denver Public Library—recordkeeping, locating books, automated circulation—she told of the working relationship with Dr. Lefohn, saying that the Western Information Network on Energy was a "direct outgrowth" of the Regional Energy Environment Information Center established as Denver Public Library in 1977. This latter activity provides information on energy and the environment to 10 States in the Rocky Mountain area. Funding is derived from four Federal agencies:

1. Department of Energy—this agency provides an FTS telephone line to permit "collect" calls from the 10-State area, and also provides a computer terminal.

---

[135] Information in America. Library Journal. New York. Bowker. Sept. 1979. v. 104. pp. 1729–1884

[136] The White House Conference on Library and Information Services—1979. The Final Report of the WHCLIS. held Nov. 15–18, 1979. Washington. U.S. Govt. Print. Off. 1980. 808 p.

2. Environmental Protection Agency—this agency, as part of its Section 11 activity, seeks "public participation . . . because unless people have information, they cannot be expected to participate in the decisionmaking processes."

3. Department of Agriculture—this agency's focus is "to market the fact that energy/environment information services are available."

4. Bureau of Land Management—this agency has funded the Center "to help meet some of the research and raw data requirements of BLM personnel."

Ms. Cayton next talked about a proposal pending before the White House Conference on Library and Information Services as well as the White House Conference on Small Business. A separate program would be initiated to meet small business information needs. Based on the findings of a recent Department of Agriculture contract to study the needs of the small businessman for various kinds of information, the Denver Public Library system would obtain, store in computerized form, and make accessible selected information for the small businessman, and show him how to use such resources. Another proposal, for the National Endowment for the Humanities, calls for an "info-expo" project "to focus people's attention on the fact that information technology exists." This is part of the "motivation" factor discussed before the Subcommittee by other witnesses. Another facet of this proposal is to take an old bookmobile and "stock it with the innovations we can get our hands on, information technology specifically." Another experiment would be to take a branch library scheduled for closing because of budgetary limitations and convert it into an experimental lab "to serve as a learning resource center for computer technologies and skills." A final endeavor described by Ms. Cayton involves bringing telecommunications to Denver Public Library; this is a germinal project looking at the potential of computer teleconferencing, with assistance provided by the Martin-Marietta Corporation.

In closing, the panelist informed the Subcommittee that:

> We are looking very hard at the structure of a library organization and how it may have interfered with our functions and progress. The public library exists to serve information, education, and recreational reading interests and yet it is organized to serve Dewey decimal. I don't think it is going to make it. A total reorganization of the library so that structure represents function is in order.

After thanking Ms. Cayton, Representative Brown assured her that in regard to the potential of libraries, "we will not omit that from any legislation that evolves from this committee." He then mentioned that when:

> I went to the UN Conference on Science and Technology for Development in Vienna; one specific proposal that I took for discussion was an initiative by the United States in funding of library centers in underdeveloped countries. This is the most important thing that we can do for them and I sincerely believe that this can be the nucleus for the development of their information systems.

77-352 O - 81 - 10

The final panelist, Edward Zimmerman, attested to the importance of new information technologies which will continue the chain of impacts begun by the telephone, radio, and television. He noted that while there are several "Cadillac" systems—ERIC, NIMIS, MEDLINE, and the New York Times Information Bank, for example—available, they reach only "a small segment of our society." His focus would be on the "Model T" of the information era—videotext, "a system for delivering text and information services into the home using the television as a display device." Mr. Zimmerman enumerated many of the uses of such a system:

- see local weather predictions
- compare grocery store prices
- check train schedules
- obtain advice on how to select a car
- pay a bill
- vote
- send a birthday greeting
- determine which Government agency is responsible for what
- file a complaint

"Videotext technology is here now," he stated, and "it will be implemented on a national scale over the next decade." He continued by noting where such systems were being tested:

> In Britain, the British Post Office has 1,000 video text-adapted television sets in place now.
>
> France has announced its intention to place a videotext receiver in every home over the next decade. They estimated that it will be cheaper to place a videotext system in every home than to publish and distribute paper telephone directories for the next 10 years.
>
> In Canada, the Department of Communications, in cooperation with Bell Canada, has announced that a pilot project involving 1,000 terminals will be initiated in Toronto, Ontario, this year.

The Green Thumb project in this country, co-funded by the Department of Agriculture's Extension Service and the Department of Commerce's National Weather Service, is being conducted by the University of Kentucky. It is aimed at "delivering crop and weather information to farmers in rural areas," and the first test group will be 200 farmers in two counties, each with a videotext-adapted TV set, which will use and evaluate the system for one year.

Private sector organizations planning or testing videotext projects include A.T.&T., Knight-Ridder newspapers, G.T.&E., CBS, KSL-TV in Salt Lake City, and Micro-TV in Philadelphia.

Mr. Zimmerman next addressed videotext's role in providing educational support; among the areas named were:

> As a system for the delivery of courses or instructional material to the home.
>
> Alternatively, students could use videotext to access course material located at a central facility.

To improve administrative coordination by providing access to low cost computing services such as word processing, text editing, and electronic mail services.

A more economical and efficient way of delivering correspondence courses, notices of meetings, administrative materials, educational publications, augmenting existing resources.

Among the advantages of videotext, the witness said that "it is easy to use, potentially low cost and will no doubt become ubiquitous." Its limitations would include the fact that "in its present form it may be too simple for some educational applications, especially when compared with existing systems like PLATO." He noted that there may be a need for improved graphics and printout capabilities.

Broadening his presentation perspective, Mr. Zimmerman cited several other home information technologies which were in existence and in various phases of operational use:

Home video recorders

Video discs ("catalogs and encyclopedias including film footage" could be stored in this way)

Fast, computer-controlled printers . . . might replace newspapers or journals

Cable TV systems

Direct broadcast satellites.

He remarked that while "many of these technologies may conjure visions of 'Star Wars,' not to mention Orwell . . . [they] are available now . . . the institutional and societal impact of these technologies will be profound."

The final topic addressed by Mr. Zimmerman centered on the role of the National Telecommunications and Information Administration. Two categories of issues related to the support of technological advance were discussed:

1. The existing communications regulatory environment; specifically the policies and regulations established in the 1934 Communications Act which in some respects are no longer adequate to deal with new technologies, such as videotext, which combine components of technologies that were originally distinct, for example, communications and data processing . . . NTIA is working on proposals for revisions to the current common carrier regulatory and policy framework.

2. Information policy concerns which are emerging from specific new information technologies, such as privacy, copyright, access, and the implications and conditions for delivery of services to the home, such as banking or mail, through electronic media.

Upon the conclusion of Mr. Zimmerman's commentary, Representative Brown and the Subcommittee staff members raised several questions before the panel. Dr. Ostenso began by asking:

* * * what kind of statewide support systems are there for such things as communications networking, library networking, and the other kinds of information?

> Are there state models and assistance for developing these systems; do they exist at all?

Ms. Cayton explained that 35 States have legislation authorizing direct support of library services, usually expressed "in terms of the educational responsibilities of the State." Only 23 of those States actually provide funds directly to libraries. Cooperation with agencies other than libraries is difficult, she noted. Then Dr. Ostenso posed this query: "Is there anyone in a State communications network that you can call upon to assist in a new project?" Although Mr. Corey said that he had received "Lots of advice and help," but no money, Dr. Watkins replied that North Carolina has an extensive network. "We are setting up for faculty, because most of the minority colleges in North Carolina tie in with them, to learn to develop curriculum materials."

Mr. Zimmerman, in reference to State-level use of information resources and systems, called to the attention of the Subcommittee a study prepared by Robert Chartrand and Jane Bortnick of the Congressional Research Service dealing with State legislature use of information technology.[137] He was then asked by Representative Brown if NTIA was an agency that funded research in the area of telecommunications. In reply, Mr. Zimmerman mentioned two programs:

1. Public Telecommunications Facility Program, in its second year, funded at $25 million, with the grants "aimed directly or primarily at applications for women and minorities."
2. A program, in cooperation with NSF, involving the Corporation for Public Broadcasting and WETA, which is a teletext experiment.

Professor Kataoka also spoke to this point, saying that his group had:

> * * * tried to get the cooperation of a public broadcasting station in southern California, which didn't work out because one of the catches in the qualifications is that you have to work with a public broadcasting affiliate. * * * The real problem was that innovative project moneys received from the NTIA would be discounted against hardware replacement needs of the local station.

Dr. Wells addressed a question to Dr. Watkins regarding the fact that "we still have a generation of teachers and librarians who are not comfortable" with information technology:

> Does this suggest that we need to consider structural changes in the preparatory system for teachers and for those coming out of the institutions?

Ms. Cayton, in echoing Dr. Watkins' affirmative response, emphasized that the libraries also must take action in this area.

Mr. Corey next talked about the performance of 12-year-old children in the Irvine Interactive Video System, who can "come on a program on the hour having conceived the topic, organized it * * * and they can direct a dialog involving themselves and seven other sta-

---

[137] U.S. Library of Congress. Science Policy Research Division. State Legislature Use of Information Technology. Washington, U.S. Govt. Print. Off., 1977. 304 p.

tions." He termed this "a high level of organization, communication skill, and intellectual activity."

Representative Brown then talked about the use of such technology as a "cultural, educational" device where integration or student exchange activities are involved. Mr. Corey told of Irvine students exchanging video tapes with children in the inner city in Los Angeles:

> * * * by the second tape, the students were calling each other by their first names, knew one another, knew their values, what their school was like, and what was going on.
>
> We invited the kids from the inner-city school to come out for a day of visitation. The kids getting off the bus were black and our kids were predominantly white, and neither group had mixed before. They got right off the bus, hugged each other, picked out their friends by name and went off for their day's activities.

The final comment during the closing moments of the hearing was made by Ms. Cayton, who described how the Denver Public Library is placing all the cataloging information in COM–CAT, "a little computer that looks like a television," and which is popular with the children and a source of concern for many adults, who still prefer to utilize the card catalog. Representative Brown then voiced his appreciation, and said that "if we need additional specific information, we [may] ask you to submit that in writing."

VI. HIGHLIGHTS AND COMMENTARY: JOINT HEARING ON INFORMATION TECHNOLOGY IN EDUCATION, APRIL 1980

The second hearing during the 96th Congress concerned with the role of information technology in education was held on April 2 and 3, 1980, under the joint sponsorship of the Committee on Science and Technology (Subcommittee on Science, Research and Technology) and the Committee on Education and Labor (Subcommittee on Select Education).

The presiding chairman, Representative George E. Brown, Jr., remarked upon the "rather unique" nature of this joint hearing, and emphasized that:

> Actually it is a part of a much broader exercise . . . [being] aimed at focusing on and utilizing, to some degree, the new technologies and communications, computing and related fields.

He then told the audience that the objectives of the seminar would be:

> * * * to enhance the awareness of the Congress, the executive branch, and the private and public sectors of the potential educational benefits of new information and telecommunications technologies, and second, the possible social and economic impacts resulting from the widespread use of these technologies in the educational process.

Remarking that science and technology "are capable of generating both good and bad consequences," the Chairman went on to say that there is a challenge to develop the expertise which will "maximize the positive impacts of these technologies in all educational environments:" the school, the workplace, and the home.

Representative Brown then addressed the need to establish appropriate policies and implementation programs for "achieving societal goals and shaping the tools and techniques necessary to achieve broad national goals." The responsiveness of such public policies to the needs of the contemporary "information society" will depend upon the development of flexible mechanisms and institutions which are able:

> * * * to adopt technological change and to cope in a humane and equitable way with the increasingly interdisciplinary nature of scientic research and new knowledge. The time is long overdue for the Congress to address information and related technologies as a national resource.

He then charged the audience, the "experts," to "derive a consensus which will direct us toward the appropriate goals and policies."

As Chairman of the House Committee on Education and Labor, Representative Carl D. Perkins was the next Member to speak to those attending the hearings and participating in the workshop. After conveying the regrets of the ailing Representative Paul Simon, Chairman of the Subcommittee on Select Education, he said the subcommittees had decided to sponsor this hearing because:

> * * * it is time that we reassess the revolution that is occurring in information technology and the likely impact of this revolution on our educational system. We believe that it is most appropriate to do this at a time when the creation of the Department of Education marks a new emphasis on education in this country.

Representative Perkins then told the audience that "In a time of budget austerity, we are looking forward to your perspectives on the cost effectiveness and increased productivity of education programs as a result of the use of technology." Noting that it had been 10 years since the impact of technology on education had been thoroughly reviewed, he stressed that the report of the Commission on Instructional Technology (in 1970) had concentrated more on the use of audiovisual equipment than on computer-assisted instruction. Some participants would talk about the impact of home computers on education and "worldwide satellite hookups," he observed, but many schools in the United States, especially in rural locations, "are still unable to afford adequate audiovisual equipment." Representative Perkins closed by urging the participants to "address in your discussions the questions and problems of equity involved in the use of access to the new technologies."

The first witness at this hearing was Arthur S. Melmed, adviser to the Director of the National Institute of Education on the subject of technology and productivity, whose initial comment was that there are "many applications in education of the new information processing and communication technologies" based on declining information handling costs, and that there are various users for such technological applications. His topic for discussion: "the role of the computer to improve learning in the elementary schools," which is "an arena in which we now have substantial working experience with which to anchor our vision of the future."

Dr. Melmed then proceeded to divide the factors affecting school use into two categories: "structural factors" and "school process factors." In the former instance, he listed:

- acquisition cost of equipment;
- capacity and capability of equipment;
- maintenance cost of equipment;
- reliability of equipment; and
- availability and cost of computer curriculums.

He gave a broad meaning to the word "curriculums," including CAI, computer modeling, and computer simulations.

At this juncture, he noted that acquisition and maintenance costs are going down while equipment capacity and reliability are rising. Turning to the school process factors, he cited two which seemed important:

The activation energy and budget needed to overcome barriers to start-up; and

management factors and social process in the classroom.

Three barriers to start-up then were named:

- 1. the budget process, and the locus of decisionmaking to get a new line item added to the school budget;
- 2. time and leadership. Various studies reveal that the time available to principals to play a leadership role to initiate new instructional undertakings is shrinking; and
- 3. the cost of teacher training in the use of computers in the classroom. There does appear to exist at this time a growing interest in various quarters for new programs to maintain and develop new teacher competencies, including a program of teacher centers to be directed by the teachers themselves.

Here, the witness referred to identifiable congressional interest in the new "educational professions development act." [136]

In talking about the category of management factors and social process in the classroom, Dr. Melmed broached these key questions:

If adequate access time to computers and computer curriculums is available, by what criteria do the classroom teacher or the school system allocate this resource among the students?

Is the computer resource located inside or outside the classroom? If outside, how does the teacher supervise this student activity?

Whether the equipment is inside or outside, how does the teacher manage his or her time and that of the remaining students when only some are engaged in the use of this resource?

Turning to the use of "models," he indicated that "our best school use data from a narrow technical point of view" are based on a CAI or "drill and practice" model of computer use, which were developed at Stanford University by Professor Suppes and his colleagues 10–15 years ago.

Next, Dr. Melmed discussed a five-year "longitudinal evaluation" of computer-assisted curriculums, sponsored by the National Institute of Education (in 1976), which focused on several schools in the Los Angeles Unified School District. Its objectives:

* * * to assess the effects of several years of computer-assisted instruction on student achievement in each of the three curriculums: elementary arithmetic, language arts, and basic reading skills.

* * * to assess the effects of variations in the intensity of CAI on student achievement.

* * * to assess the effects of CAI in elementary arithmetic on the student's conceptual understanding of mathematical processes.

The witness then detailed, without statistical qualifications, his "rough-and-ready sense" of the results of analyzing the first two years of data:

Very briefly, the study includes mainly three experimental groups and two control groups made up of comparable youngsters attending schools eligible for Title 1 ESEA funds. The

[136] P.L. 94–482 § 151–153.

groups include youngsters from grades 1 through 6 eligible for compensatory instruction and randomly assigned among the experimental groups.

Some youngsters are assigned two 10-minute time periods per day on the elementary arithmetic computer curriculum, some 10 minutes, and some none. Youngsters in the experimental group assigned 10 minutes get an additional 10-minute time period on either of the other two computer curriculums, language arts or basic reading skills. Youngsters making up the third experimental group and not assigned any time on the elementary arithmetic computer curriculum are assigned 10-minute time periods on each of the other two. So all youngsters in the experimental groups are assigned a total of 20 minutes, while only some get 20 minutes of elementary arithmetic.

Two control groups are made up of youngsters not assigned any computer time: one for intraschool comparisons drawn from schools, housing the computer equipment used in the study; and the other for interschool comparisons made up of youngsters drawn from schools not housing any equipment.

My rough-and-ready analysis of the data is this. Youngsters receiving a 20-minute supplement in elementary arithmetic daily show achievement gains beyond what might otherwise have been expected on two separate test instruments, a curriculum specific test designed to match the strongly computational emphasis of the CAI curriculum, and the California test for basic skills(CTBS). They show more improvement on the first instrument than on the second. They show more improvement than youngsters receiving only a 10-minute CAI supplement in elementary arithmetic, who show more improvement than youngsters receiving no supplement.

Within this range of variation, zero, 10, and 20 minutes daily, for a school year, achievement gains show a roughly linear relationship with intensity, that is, more time, more gain.

While the gains from this endeavor proved to be cumulative over the first two years, he said, "preliminary analysis of the third year's data appears to show diminishing returns." He noted further that the youngsters receiving the CAI supplement might solve computational problems but still have the "same conceptual misunderstandings of deeper mathematical processes" as those not in the program. The analysis for all three years showed that the language arts and basic reading skills curriculums are "more ambiguous and uncertain in their effects on student achievement" than the elementary arithmetic curriculum. Dr. Melmed continued:

I would pay the cost for the effects on student learning of the elementary arithmetic CAI program. Beyond that I would pay the marginal cost for the effects of the language arts and basic reading skills programs.

His next topic dealt with another approach to improving writing and reading skills which was based on an idea which Professor George A. Miller called "automated dictionaries," and had characterized during a 1978 NIE-sponsored workshop in these words:

* * * automated dictionaries might serve a variety of educational purposes in the teaching and learning of communicative skills, and . . . retrieval systems incorporating the new microprocessor technology could easily make automated dictionaries widely available.

Professor Miller had then defined various types of automated dictionaries, as well as a number of "automated grammars"; the simplest of these systems would:

* * * allow a student user to designate a word, say by typing it, and receive information about the word, say its dictionary entry. He could receive that information either visually on a cathode ray tube, or auditorially by electronically generated speech.

Reinforcement of this approach subsequently came from Professor Seymour Papert who urged combining a word processor with an automated dictionary, stating that since "lexical knowledge is a component of writing and reading, its acquisition should not be artificially separated from the mastery of these skills."

Mr. Melmed then described a scenario to the Subcommittees' members and staff, "only some of which is feasible at this time:"

A student engaged in writing using a word processor with automated dictionary could be cued about a variety of language errors ranging between spelling, punctuation and incomplete sentences at one extreme, to more complex errors and instances of poor language usage at the other. For example, after completing the typing of a paragraph, the student might find himself cued something as follows:

(1) Lines 3 and 9 contain a spelling or typing error.

(2) This paragraph contains an incomplete sentence somewhere around lines 4 and 5.

(3) You use the word "development" with very high frequency. Try some substitutions for a more interesting paragraph.

(4) This paragraph contains six sentences, four of them are compound beginning with prepositional phrases, over 30 words long. This combination is generally poor writing. You may wish to try for improvement with the following changes, et cetera.

Iterating that this conceptual model is only one that is currently available, the witness pointed out that it often takes 5–10 years to thoroughly test a model. "And this is very long in comparison with the rate at which dramatic changes are taking place in the hardware that is available to us."

His next focus was on "the effects of public policy and private sector investment on school use of computers to improve student learning." After stating that student use of computers would increase, but not dramatically, during the next decade—in spite of the decrease in hardware costs—he identified other factors affecting school use: ease of access, demonstrable effectiveness, and available of quality computer curriculum. Under "*ease of access*," Dr. Melmed placed:

- natural language input and output;
- computer generated audio; and
- speech recognition.

In addressing the first of these, he said:

> * * * the problems of accepting natural language input or producing acceptable informal natural language output, which the student can readily understand, is a severe barrier to accelerated use of computers in the school. Despite the occasional appearance of a breakthrough, the technical problem of accessing a computer program using natural language continues to resist solution.

Offering the opinion that "the importance of audio to facilitate instructional use of the computer is high," he said that it must be of sufficient quality "to allow a student to listen to it for considerable periods of time without a feeling of strain." Speech recognition, he then noted, probably will not exist in a form "usable to facilitate instructional use of the computer" for several years.

In further discussing the "*demonstrable effectiveness*" factor, Dr. Melmed commenced by talking about the model to improve student learning known as "intelligent computer-assistance instruction, or ICAI," which is based on "the assumption that the student has internalized the representation of any skill he is using." Errors, called "bugs," which the student may make in the execution of a skill, are not easily analyzed, and "Only time consuming and expensive development and research will reveal the power in the breadth of application of this model to improve student learning. The witness noted that Dr. John Seely Brown and his colleagues at Xerox Park are exploring the application of this model to mathematics instruction.

In dealing with the question of the sources and *availability of quality computer curriculums* to improve student learning, Dr. Melmed said he was unable to "come to grips with a likely scenario for the development of a rich inventory of computer curriculums." Such an inventory is needed, he opined:

> * * * in order to give teachers a sense of participation in the school use of computers through the opportunity to choose from a large number, since . . . for the foreseeable future, the classroom teacher will not be a developer of his or her own computer curriculums.

In regard to the development of computer curriculums, the witness stated that equipment vendors "certainly have the capital resources necessary* * * but they have no established role in public education * * * And presumably they have other more profitable investment opportunities." The publishing industry, he said, "is characterized by many as risk aversive, and the school market for computer curriculums is certainly not well defined and established at this time."

> Perhaps some special, temporary arrangements involving public—and, in that case, probably Federal—support are necessary which can be tied to the objective of demonstrating the very highest standard of curriculum quality that we can produce with our current knowledge and experience.

Dr. Melmed, in his closing commentary, observed that "information rather than space exploration has become the dominant metaphor for the closing quarter of this century, and the television receiver and the computer its pervasive realization."

Next appearing as a witness was Dr. Dustin Heuston, chairman of the World Institute for Computer Assisted Teaching, whose presentation orally was augmented by a series of useful charts. Announcing that he would 'discuss trends that are similar for various levels of education," he said that "the dominant metaphor in education is the loving teacher working individually with the student," but that average classes of 25-30 students make this impossible; in addition, there has proven to be a broad range of ability levels among the students in a given grade. Next, he referred to studies by Conant [139] and Christiansen [140] which "show that the current educational delivery system cannot give a student more than 1 minute a day of individual instruction from a teacher." In essence, this means that a student receives 10 seconds per classroom hour. Dr. Heuston warned that unless the "loving teacher metaphor" is viewed realistically:

> * * * we will be forever chasing rainbows in our funding policies as we attempt to improve our educational system. Generally speaking, a teacher cannot devote more time than the system average to his or her students. Obviously there may be many teachers who do perform at a much higher level of performance.

His next point: "the failure of the current delivery system is that it does not allow a learner adequate productivity . . . Unfortunately, the teacher, after 500 years of experimentation, is about as productive as we can make him or her." The focus must be on *learner productivity.* The witness then stressed that:

> * * * the technology that can help the student improve the productivity of his educational experience is restricted to those technologies which have a computer present in the instructional process. It is important to understand that television or videotape on movies lack this requisite capability.

Greater demands for training, in order to enter the job market, have impacted the educational system and affected those who must try to improve it. "Thus, increasingly we are having a shortfall between the requirements for education and the ability of the delivery system to produce it. "Even more discouraging," he said, "is the fact that:"

> * * * the line representing the amount of effective instruction capable under the current delivery system has now flattened out, and no amount of additional money appears to be improving it.

---

[139] Conant, Eaton H. Teachers and Paraprofessional Work Productivity. Lexington, Mass., Lexington-Heath, 1973 143 p.

[140] Christiansen, J. E. Work-sampling. A Stroboscopic View. Educational Administration and Supervision, v 42, Apr. 1956, p. 230-243.

The contents of the witness's chart (No. 7) indicate that:

FIGURE 13.—Data suggest additional financial investment is wasted capital.

1950-1975 Educational Expenditure increased from 3.4 percent to 7.4 percent of Gross National Product, an increase of 118 percent.
National scores declined slightly after this increased investment.
42 percent of 17 year old blacks are functionally illiterate.
Coleman Report corroborated that Delivery System has matured.

In regard to the Coleman report,[141] Professor Hernstein's analysis of its implications indicated that "our educational delivery system, contrary to all public perception, is relatively equal in its treatment of its students." [142]

> The ultimate impact of the Coleman report was that it devastated educational leadership because it made pessimists out of many people. What it suggested is that if you have a relatively equal system, pouring money in is not going to affect things dramatically.

Dr. Heuston went on to say that when delivery systems are static, management usually will invest more capital in improving various components of the system; for example:

adding paraprofessionals;
increasing teacher training;
improving physical plant facilities;
decentralizing education and scheduling; and
experimenting with management-by-objective techniques.

In the words of the witness, "The problem with all of these investments [and others] is that they do not touch the fundamental limit of the current delivery system."

He emphasized that:

> In fact, we are not facing a moral problem, a discipline problem, or an example of national softness. What we are facing is a work problem.

He then told of a personal experience which illustrated the quandary in which educators find themselves:

> While headmaster of a private school in New York City, I once faced a situation where I desired to learn more about the students' individual learning profiles so that I could communicate more accurately to them and to their parents the nature of their latent abilities. In order to help me in my quest, I developed a learning research center in this tiny school. My resources, in retrospect, were extraordinary. For a student population of 500, I had 3 Ph. D.'s working full-

[141] Coleman Report. Equality of Educational Opportunity. Washington. U.S. Govt. Print. Off., 1966. 737 pp. (Produced for the National Center for Educational Statistics of the Department of Health, Education, and Welfare.)
[142] Information Technology in Education, p. 35.

time in the learning research center, 25 parent volunteers, and 7 predoctoral fellows from Teachers College of Columbia University.

Nevertheless, the processing of these students took so much time that we could not even dent the problem of getting an accurate assessment of the students' abilities and communicating these to the teachers and parents. I soon found, to my chagrin, that what I was really facing was a work problem. The amount of work that that large population of professionals could produce was totally inadequate to the needs of the problem.

Returning to an earlier point, the wide range of student ability within a given grade, Dr. Heuston stated that "the delivery system has a difficult time in assessing the learner profile of the students," and he told of once photographing a set of classroom dynamics to show how students reacted variously to questions from the teacher. He also talked about the "power of social embarrassment in public learning situations or interactions." For many students:

> Distributed work stations which allow a student to sit privately at a terminal and try to master a process over and over until the point where achieving is consummated is ideal.

Another key area which the witness termed a "weakness of the current delivery system," centers on the restriction of learning to the classroom. Personalized instruction in the home environment, or even libraries and resource centers, would do much to improve student gain, he said.

Turning next to the "learning decay problem," Dr. Heuston discussed the problems related to "updating the students with the latest information:"

> Once a student leaves the school classroom situation, the school no longer feels responsible for updating the alumnus on the latest materials because it would simply be too great a work problem. With the introduction of distributed work stations in the future, we will be able to offer refreshment at critical times for students who are about to enter a severe learning decay sequence. Thus the computer program will be able to calculate, based on individual learning profile information, when a learner will begin to forget some fundamental concepts that have been taught.
>
> By offering the capability to automatically refresh at these key times, the distributed work station will keep the learning concepts alive in the student with just a tiny fraction of the time that it would take if the student were allowed the decay to continue for too long a period. Similarly, students will be able to be updated automatically when new information supersedes data that were taught earlier.

In speaking of "instructional consistency," Dr. Heuston averred that unlike human beings, with their "cycles of boredom and stress," machines can offer "perfect consistency." Next, his remarks concerned the "system technology factor" by which significant improvements can be realized. His accompanying chart offers an analogy to a transportation system (see Figure 14), and underscores the importance of correctly combining the factors in the subject algorithm:

MORE ACCURATE ALGORITHM OF

THE SOURCES OF WORK IN

A DELIVERY SYSTEM

Number of Workers	x	Training Efficiency	x	System Technology Factor	=	Total Useful Work

FIGURE 14

> What this equation indicates is that there is another factor which provides the greatest leverage of all in most delivery systems: the system technology factor. For example, if we were discussing transportation systems, and we were using the horse, then the system technology factor would be one, representing one horsepower. If it were a car, however, the multiple would probably be close to 300, representing 300 horsepower of an automobile engine. If we were substituting the jet aircraft, then the system technology factor might be a multiple of 30,000, representing 30,000 horsepower. Please notice that no amount of improving of a worker through training efficiency can change the fundamental mature limits of any delivery system. The same is true of the educational delivery system.

The goal, Dr. Heuston explained, is to reach "the theoretical maximum in terms of what a delivery system can do."

> The task in the decade ahead will be to help harness the exponentially greater amount of work that the computer can generate for the educational delivery system in a useful way that will help children and faculty members complete their educational tasks successfully in an atmosphere that is pleasant.

The practical implications of the equation set forth above were then discussed by the witness, using a companion graph (Figure 15) containing this caption:

> What this indicates is that the proper introduction of technology will allow far more work to be done by the educational delivery system. This in turn will improve the effectiveness of the delivery system, particularly by giving the

individual the opportunity to have far more individual instruction, and raise the effectiveness of the educational delivery system to a level that is more than the requirement for training potential workers.

New Educational Delivery System

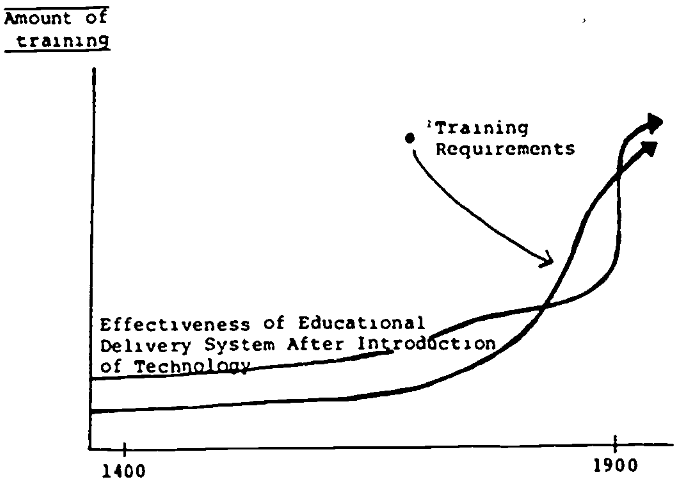


FIGURE 15

In talking about "the two most fundamental technologies of the future"—computers and lasers—Dr. Heuston affirmed that the computer's power is needed because "it can produce the type of artificial intelligence distributed locally to the student and interact with him on a personal basis." In his opinion, more or better satellites "are not going to change anything in terms of producing television for the general population that will have any impact . . . because television never has or never will be able to accomplish a significant individual interactive situation with the student."

> One of the greatest problems that educational reformers have had in using technology is that they have been indiscriminate in their use of it without understanding that only one or two of the technologies can make any fundamental difference. All technologies are not the same, and unless the computer is present, with the type of distributed or artificial intelligence that can give the personal interactive situation to the student, then very little improvement can be given to the delivery system.

77-352 O - 81 - 11

The laser, he next explained, can "be used with videodisc to store a great deal of information for student instruction . . . [and with] a much more interesting format than a computer can generate."

> Thus, it can involve color, movies, sound, motion, and a type of personal identification with thought, character, and situation that humans enjoy in watching movies or drama.

The National Science Foundation, he informed the audience, has been "deeply involved in working on these new technologies with a number of programs, and there is little question that the combination of the microcomputer and the videodisc will be the ideal instructional format of the future."

He then launched into a brief discussion of the impressive increases in industry's ability to produce storage "chips," noting that by 1985 or 1986, "we will begin to manufacture chips that have the equivalent of a powerful IBM 370 computer on them with 1 million bits of memory, all on the same chip."

> In terms of educational usage, the practical implications of these three charts are that the work stations that we manufacture for students in schools, and ultimately even in the home, will soon reach a level where the expense is not prohibitive. This is an important ingredient in attempting to produce a useful market for work stations for the schools. Practically speaking, in 1965 it cost $50,000 for one work station for a student. The work station itself did not cost $50,000, but if a computer was $300,000 and it could support only six terminals on it, then in effect the cost per work station was $50,000. Ten years later in 1975, the work station had dropped one order of magnitude to a price of $5,000. Ten years after that, in the 1985 range, we estimate that work stations will be in the $500 to $1,000 range. Thus, we can see that technologically the stage is set for the delivery of economic work stations to both school and the home markets to give the students the additional work potential with distributed intelligence present.

The use of this new distributed power should concern all of us, and to illustrate his point, he employed a chart (Figure 16) enumerating seven ways that this new power can improve educational delivery systems.

FIGURE 16.—Seven levels of contribution by technology

1. CMI
2. Drill and Practice
3. Helps
4. Instruction
5. Cognitive Diagnostics
6. Simulation (Games)
7. Learner Profile

These seven levels are listed in order to show the *practical* implications of the technology, as it is integrated into various parts of the educational delivery system.

Sequentially, Dr. Heuston then offered more detailed commentary on these seven ways of using computers:

1. CMI (computer-managed instruction)—"an important attribute not only because it helps teachers manage the instructional flow better, but also because it diffuses their anxieties about computers while it helps them with difficult bookkeeping chores." After citing the work of Harver Brudner,[143] who prepared "excellent" CMI packages, he said that many early systems are being used on home computers. In education, he said, CMI is a good introductory step for computers, since "the teacher does not feel threatened initially" due to the nature of its uses: pre- and post-test functions, diagnostics, assignments, students records, and competency based exercises.

2. Drill and practice—the research of Patrick Suppes of Stanford University, funded by NSF and NIE, resulted in some "outstanding" drill and practice materials being prepared during the late 1960's. These programs often look "deceptively simple," Dr. Heuston cautioned, but they cause the computer to:

> * * * look up and generate questions that are appropriate to the students' current level of competence, then calculate whether or not their response is appropriate, and take action if it is not. Furthermore, it has to monitor the progress of the student and change the level of difficulty of the programs if they are becoming too easy or too hard for the student. Then the program also keeps records and produces patterns so that teachers and administrators can study exactly what the student is doing in terms of useful educational work.

The advantages derived from using drill and practice include: trial with instant feedback, floating norms, private practice, ability to solidify intermittent understanding, and not being able to surmount ignorance.

3. Helps—there are two categories: "general" and "specific," which collectively "take the level of contribution of the work station up a whole level by helping the students learn how to solve a problem.

> * * * In a general help, if a student missed a specific math problem and didn't know how to do it, then he or she could call in a help which explained how to do a problem similar to the type that he had missed. A specific help is even more useful because it recalls the very problem that the student has been unable to solve and then systematically breaks down the arithmetic operations and shows the student how to solve the very problem.

4. Instruction—the emphasis here, the witness stressed, is the "development of full instructional programs that can supplement the teacher's efforts when he or she is tied up in a classroom setting," which may involve coupling a videodisc to a microprocessor. Both the faster and slower students will be better served, giving the teacher an inherent advantage because "the class will be able to learn the materials according to their own individual needs." The stipulated advantages, allow student to advance without waiting, help the slower

[143] Information Technology in Education, p 42

student through repetition, and allow rapid access to explanations of the total process.

5. Cognitive Diagnostics—Dr. Heuston talked in some detail about the difficulty of teachers discovering deep cognitive errors—such as a "zero bug" or a "lesser than greater" bug—due to diverse and time-consuming duties. He gave the example of his daughter, Hilary, a third grader, who had a "zero bug" which took seven weeks to uncover. A teacher with access to a computer work station could well have discovered the problem "within seconds."

6. Simulation (Games)—an even higher level of computer usage that will "harness the power of the chips," this type of learning is extremely important because it uses artificial intelligence:

> * * * to allow a student to have a personal learning experience where they use what scholars have called "discovery learning" strategies. In other words a program is developed which allows a student to take various courses of action, and the power of the computer is used to calculate the implications of that action. Thus, students can try various options to see what would happen if they took a specific set of decisions. Here they begin to explore the world on their own and are able to branch out and experiment with numerous variables to discover the patterns and laws that govern both the social and scientific environments.

Inherent in using this advanced man-machine approach are: discovery learning, multiple variable implications, and motivation of competition.

7. Learner Profile—the highest level of future usage for the computer, the witness said, "will have to do with research on the learner profile of the individual students."

> One use of these programs will be to establish how a student is learning as a learner, and then to convey to him or her the implications of their approach. Another use is to establish quite clearly the type of learning characteristic that that student has through genetic means. Some students who have dyslexia have severely twisted internal circuitry that does not allow them to view an O without seeing a C. It is important that we have outstanding diagnostics programs which can pick up learning disabilities when students are very young so that remediation can be effected. In fact, probably the computer will be an ideal patient source of remediation for many forms of learning disability.
>
> But even more important, this type of information will be very useful for students and parents in helping to understand the apparent strengths and weaknesses of the learner profile of the individual student. In a very pragmatic way, this should help relieve unnecessary guilt over certain types of learning problems, and it should heighten an understanding of where the strengths lay so that the students just do not feel that they are not very bright.

Dr. Heuston stated that "very little is being done in terms of establishing this type of factual material in a school because of the work problem," and for the most part students think "that they learn like everyone else learns." Not only is this not true, he asserted, but "we do not even have a vocabulary to talk to students about their apparent strengths and weaknesses." Among the critical considerations in this focal area are: audio retention, dyslexia, learning decay rate, cognitive skill and bugs, latent abilities, and learning strategies.

After ending his discussion of these seven areas where information technology may fulfill a useful role, Dr. Heuston shifted his attention to the present "climate" for using advanced technology, which in its political aspects is "very poor." He recalled the efforts by hardware manufacturers and publishers, in the 1960's, to create work stations which were simply too expensive. Many of the leaders of those initiatives "feel that they are much wiser now in the 1980 climate and they are determined never to try again." Also, he noted, those involved in the early research efforts often felt unappreciated. He then said:

> There has been much criticism of the PLATO and TICCIT projects, for example; whereas, in reality they have made a stunning contribution in advancing the entire field.

Dr. Heuston then offered this opinion about a deeper problem in this country: our "national planning characteristics:"

> In America, we want to solve all our problems in 1- to 3-year cycles. Funding is traditionally given at this level, and even if problems are beginning to become 10- to 20-year problems, they only receive a 3-year funding cycle before an announcement is made that they are a failure. The Government is the one segment of the society which should have the sagacity to develop longer range programs that are funded consistently to allow solutions to be generated and opportunities to be taken in these new technological areas. Most of the great pioneers of the 1960's and 1970's have been splintered by the funding patterns, and work of any significance has almost crawled to a halt because of the stop-start nature of the funding process: 10- and 20-year problems need 10- and 20-year funding cycles.

Underscoring Arthur Melmed's commentary on the phenomenon of hardware outstripping software and curriculum development, he lamented that "we are still in planning sessions instead of attempting to directly fund software development before the hardware is totally out of hand." Some software now being developed is "very, very poor," and is appearing because of the commercial opportunities, but this can lead, the witness warned, "to a rather severe backlash from the user community who will think that this type of software is all that a computer can do." He stressed that our leadership must help insure the development of outstanding materials which can "serve as models" in the years ahead.

Another concern of Dr. Heuston's centered on what he called "the inhumane metaphor," which is "conjured up by the use of technology in education with children." Some persons are worried, he said, because they feel it "is not healthy for the personality" to interact with technology, especially in an isolated environment. He observed that the social interaction just described "also fits reading the book;" but yet "we have grown to love books and revere them." Next, he pointed out that while "we always attach a new approach for inhumane reasons," we often ignore the inhumanity of the current system (e.g., 42 per cent of the black 17-year-olds in this country are functionally illiterate).

The final comment of the witness dealt with his belief that "computers will not replace the teacher:"

> In fact, they will enhance the role of the teacher by freeing the teacher to deal on a more personal level—a more humane level if you will—with the students. The computer will pick up the more difficult chores which the teacher has always felt have interfered with serious learning . . . Thus, we must understand that there is nothing inherently inhumane about technology, that it will not replace the teacher and the teacher's human values, and that in fact it will produce a much more human product and allow the teacher a more humane role in future educational delivery systems.

During the question and answer period which followed, Dr. Heuston was asked about the male-female breakdown in the statistics on 17-year-old black children, and referred his questioner to the National Assessment of Education Progress organization in Denver. He then was questioned about the inflation factor present in the statistics on investments in education, and was joined by Dr. Melmed in stating that "those factors did factor in inflation," but to what extent was not known.

Two problems were raised by Howard Greis from the Massachusetts State Board of Education: (1) teacher training and acceptance and (2) the high labor intensive nature of the programming process and the associated requisite retraining. As to the latter, Dr. Heuston noted that programs for school use are being prepared by outside firms, and that while these are "very expensive" to produce initially their replication is "very inexpensive." Then he emphasized that "We are developing, through authoring systems, the ability to write the programs in English without using computer programers at all," at great savings. In responding to the first question, he referred to his chart which treated the seven levels (or areas for technological application) and reminded the audience that "The best way to enter a school is to have computer-management instruction packages." Once their utility is understood, especially as concerns the CMI program ability to show why students cannot answer certain questions, then the teachers "enter a new level of concern and ask if you can produce the drill and practice material." He pointed out that:

> The publishers are now producing materials which, in effect, will start the CMI traditions, the computer management structure, and then will lead gradually to higher levels of concern.

As to the training of teachers, Dr. Heuston identified two ways: coursework in teachers' colleges, and refresher or retraining courses. Governmental help "will obviously be needed in both of these areas," he said, "because the financial commitment will be beyond the resources of any normal institution."

The next exchange focused on the development of curriculums that function on different computers, a concern of Irwin J. Hoffman of the Denver Public Schools. Dr. Heuston stated that in all probability and after a serious time lag "the Government will invest in curriculum prototypes to enable publishers to use them and modify them for their individual product lines." He observed that:

> Once you've written your basic program it is not impossible to translate them to other computers. It is important that this translation possibility be kept alive so that if a different computer becomes dominant in the market, there will be programs available for them as well.

Returning to Dr. Heuston's transportation analogy, Madeline Bates of Boston University drew another analogy to literacy, and stressed that "giving the students access to a computer as end users is one thing, but teaching them to use the computers opens up a whole new field." In responding, Dr. Heuston said that a huge percentage of a school's resources are applied to teaching languages, including mathematics and foreign languages.

> The mastery of abstract symbols (languages) will allow students to have a better future. It is important that they learn to calculate and use these symbols. The computer is certainly going to be the machine that dominates much of the future of our society, so the computer languages certainly deserve to be taught alongside the other ones.

Representative Brown then asked the two witnesses if the introduction of information technology into the home and workplace may result in the schools being bypassed "and their significance considerably reduced in our society by virtue of learning taking place . . . through the miracles of cable television, stand-alone computers in the home, training programs in the workplace?" Dr. Melmed replied that the role of the schools is "not a static one, but a changing one . . . [attempting] to respond to the demands that we put on them," and

> * * * it may well be that the sharp boundary now separating formal instruction in the school from information education outside of school will blur, with growing emphasis on the use of technology for formal education outside of school.

The topic was pursued further by the chairman, who queried Dr. Heuston regarding his earlier point "about the lack of impact of additional resources and the major technology shift." He noted that "the Congress would be glad to hear of this, because we are about to cut the school budget anyway." Dr. Heuston started by saying that the "practical implications are that there will be packages distributed for home instruction" and that parents will be able to get useful materials to help their children. Noting the differences between the home and school markets, he emphasized that early experience had shown that "students preferred straightforward materials in learning situations" as opposed to "warmed-over Walt Disney." The "efficient programs" are those that will sell.

If Congress wants to do anything with any budgets, I suggest that you consider that we have a delivery mechanism in a position to serve the schools. We have publishers ready to serve the schools but they lack the capital to develop the programs to support the school market properly.

Dr. Heuston reminded his listeners that school budgets for books and audiovisual equipment had dropped from 2 percent to 0.08 of 1 percent between the late sixties and the present, far below what the publishers used to count on. "I am afraid there will be a considerable lag between that advent of the hardware—which is upon us—and the promulgation of programs from publishers." He then expressed the personal hope that the new Department of Education will budget money for "some rapid curriculum development that can go into the publishers' domain so they can accelerate delivery to the schools."

The four panelists who had been assembled to discuss "Social and Economic Impacts of Information Technology in Education" were then introduced:

Dr. J. C. R. Licklider, Laboratory for Computer Science, Massachusetts Institute of Technology;

Dr. Maxine Rockoff, Vice President, Planning and Research, Corporation for Public Broadcasting;

Dr. Vivian Horner, Vice President, Program Development, Warner Cable Corporation; and

Dr. James Johnson, Director, Academic Computing, University of Iowa.

In his opening remarks, Dr. Licklider said that his presentation would have five parts:

1. * * * my glimpse into the early 1990's to see what education is going to be like.
2. * * * why information technology may have a major impact on education.
3. * * * why information technology is not actually having a major impact on education.
4. * * * the nature of the potential impact . . . what the effects will be if things go strongly—the effects including benefits and costs, and also the dangers involved.
5. * * * what needs to be done to gain the benefits and avoid the dangers.

Featured in the first portion of this speaker's talk was a hypothetical public classroom environment in the early 1990's, with a multi-episode scenario involving a young lady student named Cheryl, aged 15. The rather futuristic classroom learning environment features a student work area where the surface of the desk is an "interaction medium" capable of displaying images, pictures, diagrams, and pages or paragraphs of text, as well as being sensitive to what is written on it (pictures, diagrams, or hand-printed characters). This electronic desk, the locus of Cheryl's activity, contains a small computer which is connected to a "schoolwide fibre-optic network" which can convey packets of digital information among desks, computers, and data bases, plus various wall display screens and production printers.

The initial thrust of Cheryl's exercise is to explore various cultural facets of the Indian subcontinent, which requires her utilization of a computer-drawn map, replete with images of cities, towns, streets, buildings, people, and animals. She formulates a program, defining a set of 10 regions, and then calls for typical pictures of various modes of dress. A test of recognizing persons by their dress then is undertaken, with the computer checking the correctness of the guess. Having developed some skill, though with a high error factor, Cheryl wants to share her accomplishment with some colleagues, and also test their recognition ability:

> She checks to see whether or not Johnny, Sue, and Bill are on line. Sue and Bill are. They are both accepting notes at the time. She sends Sue and Bill a note. She says, "I have a neat new test for you. It will take just a minute. May I show you some stuff on your displays, or will you come over here?" Bill responds by coming right over. He likes Cheryl. Sue was not born yesterday, and she knows enough to say she'll accept output on her display.
>
> In no time, Cheryl is testing out Bill's and Sue's ability, which, of course, is almost nil, to associate pictures of the people of India with the parts of India in which they live at the time.
>
> Cheryl displays her newly won mastery and accepts the positive reinforcement provided by Bill and Sue.

At this point, Dr. Licklider told his audience, Cheryl must choose between arranging a competitive "game" involving others—with herself as overseer—or expanding the scope of her learning program. Her decision is to "take the first step toward learning how to control the presentation of information on other people's displays. First, however, she sends one of her teachers a note via the electronic message system (appearing here as Figure 17):

FIGURE 17.—Sample screen display on 1990 electronic message system.

So Cheryl sends one of her teachers a note via the message system:

To JHB.
From: Cher.
Subject: Learning the net.

How do I go about learning how to put pictures and text on other students' displays? I know I will have to have their permission. I know how to put the pictures and text on my own display. And I can put exactly the same stuff on one or more other displays by linking to the other consoles. But I want to send different pictures to different displays at the same time. I need to know about this In order to build a test game in which I can present pictures to several people at the same time—different pictures to different people—and have them respond by trying to identify or classify the pictures. It Is a neat game test, but it just works for one person now. Please help me.

Yours

CHERYL.

Z.
Send.
[Sent to JHB. Carbon sent to Cher. End.]

The teacher's response, telling her of a special meeting to discuss pertinent interrogation schemes, interrupts her reading of an article in French. Here, Dr. Licklider interjected that this on-line program features the same article in both English and French versions, with interconnecting pointers which allow transitioning back and forth between the two languages. He then told how she can place her French program on "hold," and move into another activity area. The final sequence involving Cheryl, in the witness's oral testimony, treats a Q-and-A exchange with the computer (called "KB"):

KB. What do you have about the costumes and appearance of people in various parts of India?

And KB replies: I know many things about the people of India, the styles of clothing that are worn in the various parts of the country and by the members of the various castes, and the appearances of the various ethnic groups that comprise the population of India.

Do you want to ask me specific questions, or would you like a brief summary of what I know about this topic?

Dr. Licklider concluded his scenario on education in the 1990 decade by saying that he wanted to suggest:

That education can be built into an interesting, social, active way of life. The individual student can take a lot of initiative and choose directions that are interesting to him or her.

That educational technology can provide a stimulating environment for learning, and that such an environment is to be preferred over machines that cram information into people. I am against the cramming.

That educational technology can introduce both efficiency and effectiveness into the lives of teachers, by giving them the time and facilities that they need to work effectively with individual students. The technology should do the part of teaching it can do best and free the time and energies of the teachers for inspiration and reinforcement.

That a lot can be done with the techniques and methods that are already understood.

That there is time between now and the 1990's to develop some sophisticated knowledge-based systems, but even then there will still be continuing work on such systems. The sophisticated systems will not have displaced the standard stuff.

That the educational computer-communication systems of the 1990's will deal with images quite as well as with numbers and symbols. They will work with speech, too, but perhaps a bit less well.

That students in good learning environments will feel some stress from having so many interesting avenues to explore and from sometimes having to make painful choices among attractive alternatives.

That students can be creative and valuable sources of educational software. I believe that very strongly. In my budget estimate, half the software money goes to professional programing shops. The other half goes to extracting software from the process of education. It goes mainly to teachers and students. I know that at the college level, students can create useful programs. I am pretty sure that will filter down into the high school. Perhaps it will go even further.

The use of comp ers will blend into the programing of computers, and students will do a lot of their learning by programing, by preparing and testing programs that help them interact with the information and knowledge that is available to them.

The computer-communications system of a school will be a distributed system, a network. It will be part of a network of networks that will reach across the United States and perhaps into other countries. I did not go so far as to put Cheryl into direct communication with students in schools in India, but I was not inhibited from doing that by any essential technological barrier.

In a philosophical vein, Dr. Licklider then acknowledged that through participating in the hearing, he had come to realize that "a lot of us know . . . and believe the same things . . . the key to all of this is to figure out how we can start moving."

Turning to his second focal area—why information technology may have a major impact on education—he read one paragraph from his prepared testimony concerning the rapid advances in information technology:

> The personal or hobby computers that you can buy at the computer store today for $750 are more powerful and faster and hold more information than the first core-memory machine I had the pleasure of working on. It was the very first production PDP-1 computer, the first production computer made by the Digital Equipment Corporation, and it cost about $150,000 in 1958. That is a cost-reduction factor of more than 200 in 22 years. The factor of speed increase is about 10, from 10 microseconds per instruction execution to about 1 microsecond. The factor of increase in processing power per instruction is smaller, and we may neglect it for the purpose of showing that the double-every-two-years rule checks out. Just not that the factor of 200 and the factor of 10 combine to yield 2000, which is almost exactly the result of 11 doublings, one every 2 years for 22 years. Eleven doublings yield a factor of 2048.

His discussion of the evolving technologies, including laser printers, magnetic bubble devices, and electronic beam services, then focused on videodiscs, both analog and digital. He illustrated the utility of this innovation with a true story about an MIT friend:

> * * * Nicholas Negroponte, runs a beautiful laboratory in the School of Architecture in which he and his associates work on computers in support of architecture. They went to Aspen, Colo. They photographed the roads and streets at 10-

> foot intervals. Then they transferred the pictures on to a video disc controlled by a computer. You sit in the driver's seat of an automobile, turn the steering wheel, and drive around Aspen. As the vehicle moves down the street and around the corner, the computer selects and presents the view that you should see. The trip is a bit jerky because the photographs were taken only every 10 feet, but the effect is real and compelling. With 50,000 pictures on a video disc and video discs at $10 each, one could store 50 miles worth of pictures taken just 1 foot apart for the cost of an airplane ride from New York to Aspen and back. So much for travel in the future. If we ever got into a bad energy shortage, computer controlled video discs will help.

Next, Dr. Licklider talked about software, stating that "we are over the hump on several software problems. The good programing group can now make big programs on schedule." In referring to educational applications, he said that the software costs were estimated to be only half of the hardware expenditures; the reason was that replication costs little and this will be a big factor in planning future systems. "Productivity" problems in the United States, the witness emphasized, are severe. "It is clear that our on-the-whole terrible performance in education is, in large part, responsible for the decline." Japan and West Germany, on the other hand, are doing relatively well. He expressed the belief that "the key to reversing the decline is part education and part information technology. Good use of information technology in business and industry would help us greatly. There isn't any other way to get productivity turned up in a short time."

> To make a major difference in education will take a decade. I think we may just have to learn to live with one-and-one-half-class citizenship in the world community for a few years. And during that few years we had better "get ourselves together."

In discussing the "quality of life" Dr. Licklider admitted that gasoline shortages may curtail travel, but "learning to explore the world of knowledge, to explore information bases, and knowledge bases, can be quite as interesting, quite as exciting." He then spoke of the "compelling" impact of working with a system such as ARPANET, and how on-line interaction is "a better addiction" than drugs. There are dangers in using technology, and educational applications should not be "driven only by the forces of the marketplace," since "would-be exploiters" may sell "a lot of inferior stuff before the good stuff is developed." Another danger involves an undue emphasis on factual information that is:

> * * * easy to "input" into the "computerized" and "netted" [systems] * * * government or other ideological organizations will exploit the image of the computer as all-knowing and infallible. If the schools were "computerized" and "netted" and the Government wanted to control the students, technology would present an awfully efficient way to do it.

And finally, he said, there is the danger that "technology will turn out to be so effective that it gets into the schools over the dead bodies of the teachers and, in the process, creates a disruptive adversary situation in the schools." He suggested, in closing, that thinking about such dangers should be periodic, and "not left entirely to the antitechnologists."

> We can't allow technology to shape education to the profit or convenience of technologists or to the will of political ideologists. Equally, we can't allow ourselves not to use technology just because powerful forces are dangerous.

Dr. Maxine Rockoff, Vice President for Planning and Research at the Corporation for Public Broadcasting, began her testimony by identifying four points of special significance:

> 1. * * * it is unlikely that we will have a technology revolution in education * * * it is not in the Nation's best interests to have one.
> 2. * * * there are less ambitious goals that we could adopt as a national policy * * * universal computer literacy [is] one such goal * * * even this is too expensive in terms of tradeoffs that may be required.
> 3. * * * we should settle for computer comfortable as a national goal.
> 4. * * * speak to the possibilities with respect to private sector involvement that could help make this an achievable goal.

The witness stated that use of technology "has to be in the best interests of those directly affected" to be adopted. She then selected an example of a situation reflecting this principle from her written testimony:

> In one rural clinic in Oregon, we had nurse practitioners who were backed up by a physician 55 miles away. We had a two-way slow-scan television system installed that was relatively inexpensive and relatively simple. On its face, it appeared to be cost effective in that the cost of travel that was averted on the part of the patients from the rural area were more than the cost of the technology itself.
>
> However, after the Federal funding ceased, the technology was removed. When we went back and asked why the technology did not become adopted, the answer in part was that the technology was not in the best interests of the people that had to adopt it.
>
> The physician involved in the project was really not interested in saving patient travel. In fact, his interests were best served by increasing patient travel. He was looking to the rural areas because the urban community in which he was practicing was becoming tight with respect to an oversupply of physicians.

After expressing doubt that "teachers are going to adopt labor-saving devices," Dr. Rockoff questioned the desirability of having a technology revolution in education, pointing out that "it is not just the capital costs; the opportunity costs must also be weighed." She went on to say that her goal, in lieu of computer literacy, would be "computer comfortable" which equates to "the ability to interact with an inanimate but intelligent object or device comfortably." The example chosen to illustrate this point was the Metro rider's growing adaptability to interact (indirectly) with a computer, with a high probability that other related functions (e.g., obtaining route and scheduling information) will be added in the future.

The witness then posed the question: "What Government actions and investments are needed to assure that all of our citizens become computer comfortable?" Her answer was based on the perspectives of the user and the private sector:

> First, there are important publicly supported experiments and demonstrations that lie outside the education system. For example, we at CPB are supporting a Teletext experiment in partnership with the National Science Foundation, the HEW telecommunications demonstration program, and the National Telecommunications and Information Administration to explore what kinds of public sector and private sector information could and should be provided to the home television set as part of the broadcast television signal.
>
> We want to know what kinds of information the user will want in this form, whether it is information concerning the availability of services for the elderly, health-care tips, menu planning, television schedules, weather, or the like.

Dr. Rockoff stressed that experiments such as these are important to "define what the potential for technology is, much as the experiments in technology in education were essential for defining the possible future that Dr. Licklider has drawn so excitingly." She went on to say that not all of the investment must come from the public sector, and mentioned several areas where the private sector is making major investments:

- the office of the future;
- electronic banking;
- airline scheduling;
- electronically delivered stock market information; and
- satellite-based data communications.

Also, "industry is making significant educational investments to teach people how to interact with the necessary devices. Her second question, again answered in the negative, concerned whether "the entire educational burden [should] lie completely in the private sector?"

Next, Dr. Rockoff talked about a device called "Intellivision," marketed by Mattel, Incorporated, which through adding a computer keyboard "goes well beyond the by now traditional television games" capability, offering "individualized tax preparation, stock analysis, astrological forecasting, and guitar lessons." In addition, she continued, this product:

> * * * offers The Electric Company's arithmetic and spelling lessons for 7 to 11 year olds. The Sesame Street graduates, the 3 to 5 year olds, will be computer comfortable without even knowing that they are, in fact, interacting with a computer as they play these games. Small children will become skilled at interacting with an inanimate but intelligent device. I predict that such children will accommodate easily to

more sophisticated information processing tools as they grow up. If technologies like Intellivision become widespread, they will go a long way toward assuring the minimum level of computer comfortableness that I am advocating.

Two key queries for the education professionals next were voiced:

How can we take advantage of developments taking place in the private sector as information technologies are being adopted there?

How can we identify and then prevent or ameliorate their many potentially harmful social consequences?

In connection with the latter question, she stated that the dangers of a technological revolution in education "are going to be even greater if the profitmaking private sector drives the technologies. Among those concerning her: "dehumanization, propaganda instead of education, emphasis on facts over concepts, and, most importantly, inequity."

In conclusion, Dr. Rockoff iterated her salient suggestions:

There is unlikely to be a technology revolution in education, given teachers' probable resistance to adopting teacher-saving devices.

Universal computer literacy would be one possible educational goal that would require a substantial investment, albeit a smaller one than would be required for a technology revolution.

I would settle for computer comfortable as a goal rather than computer literate, given the tradeoffs with other educational goals.

I see promising developments taking place in the private sector, such as cable-driven television learning, which makes me optimistic about our chances for achieving this more modest, but still challenging and exciting goal.

The next witness was Dr. Vivian Horner, Vice President of Program Development for the Warner Cable Corporation, who remarked about the similar knowledge and views of those participating in the hearing. She then quoted a section from Les Brown's book, *Keeping Your Eye on Television*,[144] which offers "an accurate picture" of our changing relationship with the television set. It tells of "dazzling new kinds of television . . . the gifts of an exploding technology. Individually or in combination, the electronic marvels that are now bidding for a place in the scheme of national and global communications."

* * * could touch off a second television revolution or one that might deal a severe jolt to the existing commercial television system and profoundly affect the way consumers use the medium. Through these new delivery systems with their special components and antennas, the ordinary television set may take the place of the bygone neighborhood movie house and could become an extension of the opera house, football stadium, library, university classroom, church, town council

[144] Brown, Les. Keeping Your Eye on Television. New York, Pilgrim Press. 84 p.

> and the hospital emergency room. We can foresee these sets serving as a burglar and fire alarm system, a home computer and a receiving unit for electronic mail.

The witness noted that "It sounds like tomorrow, but it is today . . . [and] is the most fundamental fact that we, as educators, must recognize."

Her next series of remarks dealt with the innovative, interactive cable television system in Columbus, Ohio called "Qube." Allowing subscribers, through pushing small buttons on a small home console, to respond to certain programs, it has been called "talkback TV," "participatory television," and "the ultimate democratic tool." As described by Dr. Horner, those subscribing:

> * * * have the choice of viewing uninterrupted movies; watching the OSU-Purdue football game without commercials; participating from their homes in a book club discussion of Follett's "The Eye of the Needle," taking a course for credit from home; asking and answering questions via the home terminal or via telephone; attending a community planning board meeting and letting their views be known without leaving their living room. And while they are doing any of these things, or even while they are not at home, the same computer that makes these video options available is monitoring burglar, fire, and medical alert systems in their homes.

Then, the witness shifted her attention to "the confluence of computers and communications," which is "at the heart of the changes that we are here to examine." Citing her five years of serving as Director of Research for "The Electric Company" at the Children's Television Workshop, she noted that "I believe that I came to understand what broadcast television, at least as an educational instrument, can do and what it cannot do." After stating that the pluses include breadth of reach and commonality of experience," Dr. Horner set forth two "telling shortcomings:"

> * * * it is a medium of scarcity—that is, access to broadcast time and space is severely limited.
>
> * * * if one-way . . . the educational broadcaster can only control the audiovisual stimulus which is only one crucial factor in learning.

"I look to the emerging electronic technology," she said, "to go beyond these limitations."

At this juncture, Dr. Horner remarked that cable technology, and perhaps direct satellite-to-home transmission, will offer large numbers of channels for home consumption, which in turn will open up educational possibilities at home such as:

> college-credit telecourses;
> self-instructional programs;
> continuing professional education;
> lecture series; and
> special needs programing.

And even more importantly, she noted, "the pairing of computers and cable has created the possibility for educational television to be a two-way process."

In differing with Dr. Licklider, she stressed that there is:

> * * * ample evidence from research in the psychology of learning to indicate that interaction is a vital ingredient in the learning process. I would not recommend extensive financial resources be allocated to investigate whether interaction is important, but only that funds be allocated to determine the kinds of interactions which are necessary to create sound learning, utilizing the new technologies, and to create and sustain environments that can maintain the results.

After commenting about the probable future "democratization of the learning process" through the use of small computers in the home—at an even faster pace than in the schools—she underscored Dr. Licklider's belief that good software, "the creation of appropriate learning materials," and the creation of appropriate settings for man-machine interface are vital. Decrying our casual concern for "the humane use of * * * hardware to solve our human problems," Dr. Horner opined that "we have an opportunity to do some intelligent advance planning." She pointed out that technology will:

> * * * take care of itself and the economics of the marketplace will see to its rapid spread throughout the society. But a major and sustained effort will be necessary to insure quality and coherence in the educational uses to which this technology is put. The British open university experience may offer us an instructive example. They recognized that public broadcast television could bring one kind of experience to many individuals at once, and thus be very cost effective. They also recognized that television could not do the job alone. Appropriate print materials, regional tutoring centers, uniform accreditation procedures, a tight line on quality, all contributed to the success of the British open university.

Educators in this country must plan similarly, she said, and take steps to "create a pool of people who understand the new technologies, as well as the needs of education:"

> We need to divide the learning process into those features which lend themselves to interaction with the technologies and those which do not, so that learning networks can be made functional and the necessary roles of people defined. Above all, appropriate learning materials, video, audio, print, computer software, and so forth must be collated and created, and people trained to access and use those materials for creative problem solving.

In completing her oral testimony, Dr. Horner emphasized that schools "need to be thought of in a broader sense, as facilitators of the learning process rather than as primary locations for it * * * educational institutions will need to recognize that learning occurs in many places and in many ways."

> The task of those institutions will be to insure that the sequence and quality of learning experiences are right and that learning for the individual has indeed resulted in a specified degree of mastery.

The final speaker of the morning was Dr. James Johnson, Director of Academic Computing at the University of Iowa. He informed the audience that his focus would be on higher education, and that the work of which he was most proud, called "Conduit," involved the dissemination of computer-based instruction materials in higher education. Conditions there, he said, "are quite different than they are in the rest of education * * * technology is not widely used in instruction today."

> In fact, in a survey that we did a couple of years ago, we found something like 60 percent of the departments of biology, mathematics, physics, and chemistry made no use of the computer in undergraduate instruction at all. Where the computer is used in instruction, 40 percent of the time it is as a tool or object of study. It is not used as a delivery mechanism for instruction; it is used to teach programing; it is used to teach data analysis; it is used in information searches. But it is not widely used in instruction.

The witness went ahead to say that during the next decade there would be a dramatic growth in higher education use of computers; four reasons were given:

> 1. * * * it falls on higher education to train people for use in industry and to develop new research techniques and new methods * * * We produce people that have to go out on the first day and be a teacher * * * the rest of the economy is going to put very heavy pressure on higher education to train the people in using computer technology.
>
> 2. Unlike elementary and secondary schools, attendance in higher education is voluntary . . . the focus can be on the learner, not instructor . . . Students are going to demand new technology, and colleges are going to have to provide it.
>
> 3. * * * the colleges and universities have a great deal of competition in research . . . research results are measurable. That forces instructors and researchers to go out and get the funds * * * to provide themselves with the latest technologies so that they can keep competitive and current.
>
> 4. * * * in higher education . . . people can get computing by themselves * * * it seems that every laboratory in the University of Iowa has a microcomputer * * * for data gathering.

At this juncture, Dr. Johnson offered insight into how computers are handled within the budget process:

> A lot of estimates of computing on the university campuses point out as little as a third of the expenditure as actually explicit. That is, only a third of it shows up in the budget for computing. The rest of it is hidden away in departments and in departmental purchases.

He then expressed the belief that "computing costs are going to increase to higher education very dramatically," based on this reasoning:

> A lot of people in engineering today are saying that we ought to provide our students with computers for computer-assisted design capabilities * * * It is an add-on cost * * * There is no corresponding increase in productivity to the educational institution itself.
>
> * * * there is going to be a heavy startup cost . . . this requires capital and labor expenditures initially . . . the investment today is not going to give us any cost savings in the next 5 to 10 years.
>
> * * * the structure of higher education changes. Business schools and computer science departments are growing * * * In computing you have to increasingly compete for the faculty members with the outside * * * When you hire them, you pay them twice as much as a professor of mathematics.
>
> * * * accessing information throughout the world rather than locally . . . becomes an external cost to the institution; they must take money out of their pocket and pay somebody with real dollars.
>
> * * * most colleges and universities have been relatively self-contained * * * To do something new we have the faculty work an extra 4 hours . . . having to go out and get resources from other places rather than from a "free" labor resource or a cheap labor resource will increase the cost of education.

Dr. Johnson next examined the ways in which institutions of higher learning might move to cope with such increased costs: through creating larger courses, increased specialization of curricula, and instituting "electronic offices to get increased productivity." He warned that this may mean that "We are going to implement the worst example of computer technology to solve our problems very quickly by reducing costs." In some instances, computers already are being used to help students pass tests, "and we . . . forget about whatever else is going on in the educational process."

> At the University of Iowa, there is a course in medical terminology, Latin and Greek. It has virtually no instructor and no class meetings. It is all computer-assisted as an approach there with testing at the end. They r[illegible] something like 200 of the students a semester through that particular course. This may be appropriate for this course but is it for all?

And finally, he said, "we will finance the new technology with higher tuition."

It was the opinion of the witness that the application of the new technology cannot be delayed, because the "biggest crisis we face in education generally, specifically in higher education, is loss of confidence." Three groups are evincing displeasure with the present situation:

- Employers are mad at us because we don't train people the way they want them trained.

- Students get mad because they can't get jobs.
- Most importantly, the educators themselves are sitting back and saying, "We're spending all this money for computers. What happened to traditional arts?"

After describing the differences between his children's classroom—"something out of the 19th Century"—and his modern, technology-supported office environment, Dr. Johnson concentrated on funding problems:

> Then we start asking questions. We start saying, "Well, couldn't we, as a university community, spend more money on education? We can go out and vote and spend more money on education?" What happens then? The state says, "You can't spend any more money on education." We have equalization laws. Every district has to spend approximately the same sum of money. If you want to spend more, State aid then goes down. There are a lot of pressures to prevent you from making changes. This reflects on our Government because education is perhaps one of the first places where we all deal with government. This is a very serious personal concern that I wanted to share with you.

In his closing remarks, he stated that artists, poets, and novelists as well as computer scientists and economists should be considering the long-term impacts of computers. Just as the book *The Third Wave* [145] deals with the potential of computing and communications technology for "fragmenting our society," Dr. Johnson warned that the future is "not a straight-line projection from the past" and that we may be faced with a "total discontinuity."

The first question to the panel came from Alfred Bork, Educational Technology Center, University of California at Irvine, and dealt with "our chances of obtaining extensive funds for curriculum development, either through the Government or through some sort of combination of Government and commercial concerns." He noted that "It does seem critical for the future that we have some coherent development of full courses that involves a computer as an integral component." Since there was no reply from the panel to this query, that of another attendee, Allan H. Levy, School of Clinical Medicine, University of Illinois (Urbana), was entertained. Within the context of the "increasing confluence between communications and computers"—and here he noted his awareness of the PLATO system's utility—he asked for "ideas as to how we could evaluate the effectiveness, in professional education, of what I see as a tremendously useful tool in professional development." Dr. Horner, who reflected her involvement with "several attempts to use cable television for continuing professional education," differentiated between whether a system (such as PLATO) is valuable or not, and "whether you can get done what you need to get done and learn what you need to learn, and get properly accredited for it". Some professional groups (e.g., the American Medical Association) are commencing to give continuing education courses. Dr. Rockoff added that in evaluating the technology "it is important to assess who pays and who benefits."

[145] Toffler, Alvin. The Third Wave. New York, Murrow, 1980. 544 p.

In a change of focus, Harold Beder of Rutgers University reminded the attendees that "Little has been said as to how educational technology may, in fact, change" the educational system. He then asked Dr. Licklider what purpose the public schools, "as constituted today," might play in the 1990's scenario. "It seems to me," he said, "that Cheryl could do her thing in her home, the local library, or virtually anywhere, as well as in something called a school." Dr. Licklider, in response, cited the importance of "social support" for encouraging such activities. Although believing in "the distributed intellectual community," he opined that "some face-to-face meetings first [would be] in order to get acquainted, to establish rapport." He continued by saying that "if the school is not receptive but hostile," other alternatives will emerge, such as commercial schools or education in the home. Dr. Johnson then underscored the criticality of "certification and granting of degrees," and said that once control of the accrediting process is taken "out of the hands of education . . . then you grant the option for the private sector to enter the market or for people to do it on their own at home."

The topic of "cultural diversity" was the focus of the last questioner, Dania Stager-Snow, Graduate School of Education, Rutgers University, who stated her belief that "I do not see that democratization will occur across classes . . . technology will increase the gap between lower and upper classes." Her concern: "how is the technological revolution going to handle cultural diversity?" Dr. Johnson, in response, talked about the ability of some parents to "deliver" more education at home than others, adding that "I think when people talk about adding diversity they are simply saying that this technology allows for greater individualization of what you're doing."

Appreciation was expressed at this point, by Representative Brown, for the panel's willingness:

> . . . to help us in the Congress to appreciate the complexities of this very important problem of the impacts of converging technologies in computers and communications on the field of education . . . as we move into a postindustrial society. Congress is just beginning to wake up to the importance of this.

These opening remarks at the seminar luncheon following the morning session were succeeded by the Chairman's noting the presence of:

> Senator Harrison H. Schmitt—[who] has played a very key role in a number of important areas involving technology, including this one.
>
> Representative Lionel Van Deerlin—chairman of the Communications Subcommittee [who] is trying to grapple with the problems that are involved in the regulation of the communications industry.

Representative Brown went on to say that "we face a technological explosion which will have impacts in a number of vital policy areas . . . issues such as privacy and democratization of this technology, its effectiveness, of how various parts of the spectrum of technology will be divided between the public and private sectors, or various parts of the private sector." Acknowledging that such efforts "take considerable time," he assured the attendees:

> . . . that information and its impact on society is moving to the top of our priority list. We will be involved in it for years to come.

The challenge before the Congress and all concerned about this focal area requires:

> . . . that we have to try to put this tremendously, rapidly expanding, complex field into some perspective that will allow us to grapple with it in a coherent way within institutional systems which are not used to grappling with things in a coherent way.

On April 3, the Subcommittee reconvened, and the first witness was Dr. Charles Mosmann, Associate Vice President for Academic Resource Planning, California State University at Fullerton. Having been asked to talk about "our capabilities for evaluating new educational technologies . . . and the need for information on the part of individuals and institutions who need to make such evaluations," he chose to make three major points:

> 1. I should like to remind you of some of the reasons why the use of computers in instruction is complex and how this makes questions of evaluation difficult
>
> 2. I want to tell you what parts of the evaluation question, again regarding the use of computers in education, can and must be answered.
>
> 3. I will suggest how we might obtain better answers to those questions and how we might get more mileage out of the answers we do have.

To make decisions affecting the future, he said, educators "would like to know how computers have affected education in the past." Dr. Mosmann then pointed out that "computers have had as strong an influence on the content as on the method of the activity." Calling the computer a "sort of intellectual steam engine," as it is viewed by many, he argued that perhaps it is "really more like a telescope [since] . . . It changes human vision and thus imagination and thus ultimately human goals."

> Computers in education have made our lives more difficult and not easier, as we were promised. The computer has not brought us closer to our goals, but has helped us to see further and thus to advance our goals, so that we find we have even further to go. Have computers helped us to achieve our educational goals? I think the answer is "No." But at the same time, they have made the question irrelevant.

Noting that early projections saw the computers "as a machine to replace human labor . . . the ultimate 'teaching machine,'" Dr. Mosmann commented that it is not just "a passive machine for delivering information . . . [but] has provided a means for giving students a much greater insight into the world in which they live."

> Of the greatest importance in the expanding of computers in education has been the need and the opportunity to teach

> students how to use the computer in the activities they plan to pursue after leaving school. The computer has assumed an important function in the contemporary practice of business, industry, science, and scholarship. Its impact on the professions and the arts is growing. Almost no student can expect to remain untouched by this tool of almost universal applicability. So by changing the world of work, the computer imposes an additional burden on education: prepare students to assume jobs where they will use the computer as a partner.

He went on to explain that "large numbers of students now use computers to do things that would have been meaningless a generation ago," including techniques for problem solving and those allowing an expansion of their knowledge.

Next, Dr. Mosmann discussed the role of computers in the social sciences, with emphasis on their advantages and dangers within the context of social impact:

> Some schools have recognized their obligation to review with students the social issues that the computer and its allied technologies have introduced, issues of which the rights of privacy and the impact of automation on employment are best known.
>
> As a consequence of these factors, schools and colleges find themselves pressed for expanding the curriculum by students—many of whom expect schools to provide them with access to computing and instruction in computer-related subjects—by the market for graduates—for employers are coming to expect applicants to have some basic computer literacy before they arrive on the job—and by the general needs of our society at large.

Admitting that "it is clearly impossible to assess the value of computers in instruction in any absolute way," the witness addressed his second point which focused on answerable questions affecting this situation:

> * * * how much computing do students need?
>
> * * * what kinds of computing do schools need?
>
> * * * since usage patterns diverge widely, how do you encourage students and teachers to make productive use of the resource, once it is provided?
>
> * * * how do you tell the difference between productive use and its opposite?
>
> * * * how does an educational institution go about answering these questions on its own, for the questions must have at least tentative answers in order for an institution to fit computing into its own institutional priorities.

Dr. Mosmann told of trying to formulate some answers to these questions in a handbook called "Evaluating Instructional Computing: Measuring Needs and Resources for Computing in Higher Education." [146] While no ultimate answers were provided, it "indicated some directions and warned of some dangers." And although he had "hoped

[146] Mosmann, Charles. Evaluating Instructional Computing. Irvine, California, University of California, 1976. 88 p.

to assemble facts and arguments to support some fairly straightforward advice and precise recommendations," he discovered that there were "just no authoritative pronouncements."

> One of the basic conclusions of my study and thus one of the premises of my handbook was that no universal answers are in fact now possible, but that each institution must work out its own decisions, based on its own priorities, the goals it puts forth for its students, the abilities of its faculty, what its community thinks are the priority and value of computing.

The witness explained that his study did suggest several alternative techniques, and in particular, "stressed the value and importance of better measures of the quantity and quality of computing" for teachers and students to use. Also, administrators and teachers need data that go beyond simply "how much" computing was used. Techniques of cross-institutional comparison and peer performance evaluation can be useful. He next stressed that institutions need "means of assembling consensus on what their present and future needs are;" surveys should include, as well as teachers, the alumni, students at higher levels, graduate admissions offices, and employers in the community. But, he insisted, "the ultimate help in deciding where computing belongs in the priorities of education would be some hard data on what its impact has been on those being educated."

Here, Dr. Mosmann began focusing on his third major point by saying that there are two groups of students, some who received liberal amounts of computing support and others who did not have such an opportunity. Certain questions were posed:

- What measurable difference can be discerned between these groups?
- Does the use of computers in instruction make any difference? If so, what is it?
- Is 20 terminal hours per year enough exposure for the average student?
- How much better would a student's education be if that number were doubled? How would it be affected if it were halved?

The data to answer these questions do not exist, the witness stated, but "a sufficiently careful and detailed effort might bring them into being." Such a project would be "no trivial undertaking," and would "require examining a range of institutions of different quality aspirations * * * [and] will call for surveys and longitudinal studies of both institutions and students."

> Still, while we are waiting for this major study, valuable information can be gathered from other briefer reports. Most of the data we have on computer use in education are based on computer center records regarding how many of the resources different groups use. Very little effort has been made to ask the faculty what their students are doing and why. Almost no systematic investigation has been made to find out what students really do in the hours they spend in front of computer terminals. Only the students have a large share of the most valuable information we want. It is hard to get good and reliable information from students, but if we learn to ask the right questions, they will tell us what we want to know.

Dr. Mosmann continued, saying that more studies were needed to record the expectations of instructors as they assign computer-related work. In addition, he identified the need for more research to help understand "what kind of education is taking place" when the man-machine interface is underway.

The final suggestion of this witness dealt with an appeal for "better use of the data we have—limited and inconclusive as it may be." The focus, then, would be on the evaluator. In this regard:

> * * * the issue of evaluation is important only after the decisionmakers in education decide that the questions of evaluation are worth asking.

Lamenting the fact that many administrators and teachers "just do not care or—and this comes to the same thing--claim that they do not have the skill . . . lack the time needed . . . cannot afford the cost," Dr. Mosmann declared that:

> Students learn from teachers, and teachers learn from professors of education. Before students can learn from computers, the entire structure of professional education must become aware that computers exist and that they are relevant to educational concerns in a very broad context.

"Information technology," he insisted, "must be seen as an opportunity for improvement, and not a threat . . . it must be seen as important across the spectrum of education and not a specialty only for mentally gifted minors with a talent for mathematics. We must find better ways of reaching those educators who have made up their minds before the evaluation questions are asked."

The Chairman then introduced Ernest J. Anastasio, Assistant Vice President for Research and Development Administration with the Educational Testing Service (Princeton, New Jersey). Mr. Anastasio announced that he would take a broad perspective of the topic of evaluating information technology in education, and consider the "fundamental set of issues that must be addressed in evaluating any instructional technology."

> Although the "theory" of educational evaluation is applicable across different kinds of programs, there are some unique characteristics in the evaluation of technology-based innovations. For example, it is important to distinguish between the use of technology to improve access to educational instruction by delivering materials already available through other mechanisms (an example would be the use of satellite transmission of existing TV or radio instruction to remote locations in Alaska and the Appalachians) and the use of technology to augment and enhance existing instructional offerings. In the first case, the evaluation is primarily concerned with problems of implementing the innovative system and, if successfully implemented, questions of the extent to which the intended recipients make use of the instruction provided. In the example, the contest is between instruction via satellite and delivery of no supplemental instruction at all. Because of the nature of the comparison, technology is likely to be any easy winner in this case.

He continued by saying that "the largest potential impact of technology in education is in supplementing and enhancing instruction," which makes any evaluation of an innovation "far more difficult" and forces an evaluator to make "a systematic attempt" to answer these questions:

> 1. How did the innovation work—in terms of performance quality, reliability and flexibility?
> 2. What were the costs—in dollars, in personnel adjustment and in extra support and resources?
> 3. What were the effects—the intended effects on learning as well as the unexpected outcomes?
> 4. How was the innovation accepted—that is, for any implementation, how did the stakeholders, for example, students, administrators, and parents, react?

In detailing his response to each of these, Mr. Anastasio presented both philosophical and pragmatic considerations for his audience. Those facing up to question No. 1—"How does it work?"—are confronted, he said, with the " 'actual versus potential' dichotomy."

> Most technologies are evolving. It is not possible to evaluate the "potential" of a technology, except by expert judgment on actual performance . . . When technology is not yet stabilized, the only way to answer the question "How does it work?" is to take a snapshot at a particular juncture, document it thoroughly, and use the information to improve the precision of expert judgment concerning future modications.

"No delivery system," he remarked, "can be evaluated empirically without deliverables." Evaluating systems designed to deliver and receive educational messages necessitates binding the question "How does it work?" to the curriculum being implemented. Then he stressed that the "curriculum delivered must be worth delivering":

> The temptation to exploit the capabilities of shiny new hardware almost invariably means that no "traditional" curriculum, or courseware to use the current vernacular, will be seen as sufficiently well-matched to the unique properties of the system to be readily adapted to the new technology. Thus developers embark on new curriculum development with an optimism uncontaminated by experience or by the knowledge that curriculum development takes years of trial, error, and revisions, and can consume vast amounts of resources, with a resulting product that is no better than that currently used in the schools. When such a home-brewed curriculum is delivered via the shiny new hardware, and evaluation shows it to work no better than does the traditional curriculum, the question of how well the medium could have worked if its message had been worth delivering remains unanswered, but the reaction of the education community is often to discard the system as having been proved to be ineffective. Language labs, programed texts, teaching machines, and individual filmstrip/cassette carrels are gathering dust in school storerooms all over the country, in testimony to industry's and educators' tendency

to sell and buy thousand-dollar hardware associated with $1.98 courseware, and then to become disillusioned with the hardware.

Turning to the criticality of "the authoring process," the witness affirmed that "the educational progress of students using any [computer-assisted] system will be limited by the nature of the curricular materials presented," no matter how powerful the hardware and software.

> Many project plans have substantially underestimated what is required to produce an effective curriculum, some by erring in the direction of excessive and premature systematization of materials lacking in adequate realization of the potentialities of the medium for delivery, and others by erring in the direction of excessive reliance upon highly inspired adjunctive exercises demonstrating the great versatility and creative potential of the medium, but inadequately supported by comprehensive, systematic coverage of curricular objectives.

Mr. Anastasio recommended that any major trial of a new delivery system should be preceded by "carefully prescribed, small-scale iterative experimentation, usually based on an already-proved curriculum." He then drew an analogy between training flight crews for new fighter bombers and assembling and preparing a cadre of CAI specialists who can author usable courseware.

In regard to question No. 2—"What were the costs?"—the witness spoke of the new roles required of teachers when a technology is introduced: "In addition to training time, and the costs—in terms of personnel and financial resources—of developing and delivering training material, it is necessary to consider opportunity costs throughout the teaching day." Here he drew a distinction between the system which "requires active teacher intervention every few minutes" and a "turnkey" system, which "operates completely independently of the teacher." Then, another crucial aspect of this focal area:

> When dealing with an evolving system, even direct monetary costs are difficult to track. It is clearly in the developer's interest to assign as many operational, implementation, and service costs as possible to the "development" category, thereby lowering the estimated cost of routine delivery of the developed system and courseware. If system and courseware development are allowed to proceed concurrently with evaluation field trials, it may be impossible to separate the costs. Thus, the researcher's desire to evaluate a stable treatment is not so much evidence of a lack of methodology to deal with dynamic phenomena, but an insistence that determining accurate operational cost is essential to informed decisionmaking.

There is a growing feeling, Mr. Anastasio noted, "that the most reasonable target for summative evaluation is a replication of the pilot system rather than the original, in conditions other than the developer's back yard."

"What were the effects?" constituted question No. 3, and this continues to be "the traditional question of educational evaluation," declared the witness, but there is no "simple one-number answer."

> An increasing segment of the public is aware that the question is not, how much did students learn—raw grain—but how much more or less did they learn than would have been the case if they had not received this treatment?

Another key area of public awareness concerns the fact that "a system that gives positive results with one population in one setting may give quite different results with different groups in different settings." There should be an attempt, during evaluation, to set "limits of generalization."

> The key factor, of course, is an experimental design that is appropriate to the situation. In its simplest form the design would include two comparable groups, one of which receives the innovation and one that does not. However, even this simple design is difficult to implement in practice. To the extent that the innovation is perceived as beneficial, it is possible that the group who is not receiving the innovations will find ways of supplementing their instruction. For example, if the two groups correspond to different classrooms, the teacher in the control classroom may supplement regular instruction by various means. The effect of such a comparison would be an underestimation of the real impact of the innovation.
>
> The way to deal with problems such as this is by using designs that are robust to this problem. One such powerful design, made possible by the individualizing technologies such as CAI, is the delivery of different curriculum, say reading or mathematics, to randomly assigned students in the same classroom. Then the reading group becomes the control for mathematics, and vice versa. This design has been used to good effect by Patrick Suppes for precise within-classroom evaluation and is, in fact, an important element of the design being used by ETS in the NIE-sponsored evaluation of drill-and-practice CAI in Los Angeles.

After asserting that another mechanism for dealing with this problem is "to assess the types and amounts of instruction received by the different groups and incorporate that information in the analysis," he stressed that there must be an *accurate* assessment of the impact of innovations, prior to their acceptance or rejection.

In his more intensive discussion of question No. 4—"How was the innovation accepted?"—Mr. Anastasio emphasized that regardless of the impact on achievement or other cognitive test scores, "the evaluation of a technological innovation must ascertain the attitudes and reactions of students, teachers, administrators, and parents to its intrusion into their lives:"

> Sometimes such information must be inferred from the observation of behavior, but sometimes it is more directly available in responses to tradeoff questions. For example, at the end of the Plato elementary school demonstration, teachers were asked, "If you had the choice between a half-time aide and Plato terminals in your classroom—approximately equivalent costs at that time—which would you choose?"

A majority of intermediate mathematics teachers opted for Plato, but a majority of primary reading teachers chose an aide. This sort of evidence of degree of acceptance, in terms of tradeoffs, rather than of "Would you like it at no cost?" is necessary if decisions are to be made in the real world of scarce resources. Even if a system is designed for add-on use, rather than substitution for the teacher's time, its adoption will not be an add-on in these days of taxpayers discontent, but will replace something in the budget. To be accepted, it must be seen as more cost effective than something already in use.

Because of the importance of this facet of teacher involvement, the witness prolonged his exploration with this summation:

Acceptance by teachers requires that the teacher be able to retain some professional autonomy over mode and timing of use, and instructional sequence for individual students. The system which is designed to be teacher proof, diagnosing, routing, prescribing, delivering instruction and testing for mastery independent of the teacher, makes it impossible for the teacher to integrate the system with other classroom technologies. Just as seriously, such a system leaves no provision for human corrective action when a student gives a response that the system or curriculum designers did not foresee. In the absence of omniscient designers, such unpredicted behavior is likely to take place every time a child sits down at a preprogramed device. For these instances, teacher-proof systems very quickly become teacher-rejected systems. The answer to this problem is not to design increasingly complex teacher-proof systems, but to include the teacher in the feedback loop, making the technology a tool to be used by a trained expert, rather than a fast and colorful, but mute, simulated expert. Progress in artificial intelligence may someday make it necessary to revise this assessment, but for the foreseeable future, teacher resistance to closed systems which they cannot guide will be based on sound pedagogy, and not merely fear of being made obsolete.

Stating that "many evaluation findings could have been predicted simply by looking at the content of the treatment curriculum, the comparison curriculum, and the match between each and the content of the tests used," he examined some of the intricacies involved, and then iterated that the "ultimate objective is the improvement of understanding."

Mr. Anastasio, at this point, informed the audience that Gabriel Salomon [147] had argued persuasively that new methods to measure new media impact on students' "conceptions of and styles of working in a subject" are a "high priority need in evaluation of new technology."

By observing student interactions with new technology during the important piloting phase, prior to formal summative evaluation, and by utilizing clinical interview methods, evaluators can generate hypotheses concerning novel out-

[147] Information Technology in Education, p. 163

comes, and develop instruments to assess them. As an obvious example, a system which allows a student to construct a response, rather than simply to select from among alternatives, may not be assessed effectively with multiple-choice tests. Deeper effects, for example, on the student's notion of the structure of a body of knowledge, will not be captured without major efforts to design measures which probe these less superficial structural understandings. This argument—that different media vary with respect to the kind of mental skills they activate, and for that reason also vary with respect to the kinds of achievement they produce—may prove to be the greatest challenge in evaluation of technological innovations, and may lead to different and more appropriate accountings of the unique educational outcomes that result from their implementation.

The next focal topic concerned "the role of the teacher in effecting educational reform, and the implications for evaluation." During the past 20 years, said the witness, "more programs intended to change classroom instruction were rained down on elementary and secondary schools . . . than during the entire history of public schooling."

> The nature of the desired change varied with the interests—vested and intellectual—of the reformers, and this diversity of ends was exceeded only by the varied means chosen to bring them about.

Conceptions of the teacher's role in "reshaping educational practices" have varied drastically, Mr. Anastasio stated, but:

> Given the teacher's centrality in the classroom, it is surprising that decisions about implementation strategies have often been made with scant knowledge about the pedagogical values and constructs held by teachers. The question of the compatibility of a program's goals with those of the teacher's has seldom been raised. This curious lack of interest in the teacher's viewpoint, the "odd gap" often referred to in teacher research, is all the more remarkable if one considers the universal aim of many innovations, bent on no less than the improvement of all instruction efforts.

After asserting that this problem "is not unique to instructional technology," he opined that "it seems especially appropriate to raise the concern at this time as we consider strategies to meet the challenge of evaluating innovative technology programs."

In closing, the witness iterated his conviction that:

> * * * quality evaluative data is critically important to decisionmakers—be they developers, potential consumers, funding agents, sponsors, or students—and that these data will only [be obtained] from comprehensive examination of stable systems with carefully prescribed curriculum implemented in contexts which as nearly as possible reflect the realities and complexities of contemporary school settings.

Following the two major morning presentations, Representative Brown opened the session to questions from the participants. Ken

Komoski of the EPIE Institute in New York City asked Mr. Anastasio how he would respond to "the reaction we find around the country that decisionmakers tend not to look at evaluative data." In posing this question, he explained that during a meeting with publishing representatives a student had asked "What then do you believe is the critical variable regarding persuading people in schools to buy what it is you are selling?" and the "knee-jerk reaction" was "Packaging." In reply, Mr. Anastasio offered the opinion that:

> * * * a large part of the problem is with the evaluators and the developers who have to learn to package their results in ways that will get the attention of the school boards, Members of Congress, and the like. Social scientists in the past few years have become much more sensitive to their obligation to couch and frame recommendations in terms that policy makers can comprehend and react to.

A second participant, Norman Kurland of the New York State Education Department, recalled Mr. Anastasio's reference to language labs and other technology-oriented experiences, and said that in his State school districts are buying:

> * * * microcomputers at a very rapid clip, putting them into classrooms, and then we hear concerns about whether there will be enough courseware to make them really work. I wonder why you think, if you do, that the experience with this technology is going to be any different than with previous technologies, and what your advice would be to Congress, to the Federal Government, to those of us in the States, and others to try to make sure this time that this turns out to be a really effective technology and not one that ends up on the shelves in the closet 5 years from now.

Mr. Anastasio, in reply, admitted that he was "not confident that our experience with microcomputers is going to be very much different than with other technology," and continued by suggesting that "bringing the microcomputer, or the language lab . . . into the classroom is disruptive in positive ways . . . [but] it is on the basis of that experience that we say 'this is what we need,' . . . and we contract to buy it, or rent it."

> The problem then becomes the courseware problem that I alluded to before. There is not industry behind the scenes now generating the lessons, modules and courses to follow on from the demonstration materials, and because that industry is not there, we are let down after we have had our fill of the materials that came with the machine. That picture has not changed very much in recent years, and I don't accept at all the notion that teachers will generate the material. All of us have been educated and we have all used many text books in the course of our schooling, most of which were not very good. Some of us who were lucky had the privilege of using good text books in one course or another; some of us were even more lucky and had the good fortune of running into a master teacher. There are very few master teachers, and I'm positive

> there are very few people who have the ability to develop good course material, whether for micro, mini, or whatever. I think that is true now and will continue to be our experience.

In response to a question from a Rutgers University attendee who alluded to a call for "more experimental designs" and asked whether "evaluation [can] provide a solid guide for the adoption of this technology," Mr. Anastasio iterated that he was "arguing for as much control as possible on the part of evaluators so the decisions can become clear."

> By way of example let me make reference to the evaluation that we conducted for the TICCIT project in the middle 1970's. There was a case where, with a lot of effort on the part of developers and evaluators to cooperate with one another and create an implementation of that system that was most sensible, we were able to determine that the particular instruction programs could produce a positive impact on student achievement.
>
> In a nutshell, that project showed that students who went through the TICCIT program of instruction performed at higher levels than students who did not; however, the tradeoff, the cost of higher TICCIT performance was a substantial reduction in the number of students who completed the course versus the number who didn't. Only 16 percent of the TICCIT students finished the course to get credit versus 50 percent of the students from the classroom. That was the case in math. In the case of English, it was about 50 or 55 percent of the students finishing with TICCIT, and about 66 percent finishing in the traditional class.

Declaring the design "a good one," he said that these data showed that they could be confident about the "positive impact" of TICCIT. Then, he continued, "the question for the policymaker became—can we afford to invest in this product so that we can obtain a higher level of mastery but risk having it take longer?"

Dr. Mosmann was then asked, anent his earlier testimony, if he had any suggestions about how to obtain answers to the "questions on evaluation in higher education" or "incentives" toward the answers, to such matters as, "the coming financial crises." The panelist affirmed that "the primary incentives to evaluation are budgetary. The financial pressures on education today require a more rational approach to the assessment of alternatives and the allocation of resources."

Peter Wiesner of Essex County College was the next questioner, commenting that according to Mr. Anastasio "instructional design is an integral part of evaluation, that the evaluation of course work should begin at the very onset . . . once materials have begun to be developed, they should be pilot tested and rigorously field tested before they are ever put out in the market." His query: "If Government funds are to be spent for courseware for the schools, should we require that products undergo this process?" Eschewing a "yes" or "no" answer, the panelist pointed out that most of the materials purchased in school systems are part of a "package." Remarking that he "would like to see us do better than that," he went on:

What I'm in favor of is that any project that the Government sponsors—and they've been very good about this—have associated with it the opportunity and provision for careful evaluation. The Los Angeles study that NIE is sponsoring is now in its 5th year and it ends in September 1981. At that time we will have data on a number of elementary school children who, for a period of 4 years, have received exposure to regular drill and practice exercises. This is with a system that was complete when we started, with off-the-shelf hardware, and the design that I mentioned as being the most robust is what we are using. That will give us a good basis for any decision about the impact of those materials.

Another facet of the larger topic was introduced by Steve Raucher of the Montgomery County Public Schools:

I agree very much with what Mr. Anastasio said; the problem that I sense is a Catch 22 situation, the half-life of the technology which has been primarily led by the semiconductor industry, is something like 14 months. The requirements to perform careful curriculum development and evaluation exceed that.

Do you feel there is a way to bridge this dichotomy, for example, a required standardization of software technology from the technologist's side that would be required before any curriculum development could take place?

Acknowledging the validity of this characterization by his questioner, Mr. Anastasio observed that as the move is made to higher level languages in computer systems, "there is more of a chance to get some standardization." At this juncture the Chairman interjected:

I think some of you might be familiar with the recent effort to impose standardization in the peripheral equipment to computers which raised a tremendous stink when this effort was made by the NBC, and it is a continuing policy problem which I am glad you are bringing up here. I would very much like to know what the proper way to do it is, because you are always accused of inhibiting competition when you impose standards, and you have to weigh both sides of the equation very carefully.

The succeeding question, from Allan Levy of the University of Illinois, was focused on the matter of "stability and evaluation:"

It is not only in the nature of the technology that is changing but rather the evanescent nature of funding, whether the funding be from governmental, university, or commercial. It is usually short term and there is often a requirement to either evaluate or reapply for additional funding just about as the project begins. I wonder if there is a way to begin to approach continuity in curriculum development of educational innovation in the same way as there is continuity in the more traditional forms?

The study he cited earlier, Mr. Anastasio averred, was a 5-year longitudinal project situated in Los Angeles which had "taken the full time attention of an NIE program director to see that the budget remained intact for the past few years." He went on to say that "One of the problems that has plagued the project in the past is the one you referred to, funding for a year or two and then intense pressure to produce some results."

After noting a "direct parallel" between calculators and microcomputers in the classroom, Joe Caravella of the National Council of Teachers of Mathematics explained his interest in earlier testimony about "expanding the definitions of schools." Agreeing that "Education does not only take place in the schools," this participant asked if the panelists could expand their comments to "integrated home-school educational experiences?" Dr. Mosmann's approach to this opportunity began with the statement: "Competition from other forms of education may turn out to be more practical and even cheaper than formal higher education." And while many educators may not realize it, he said, "many of the forms of instruction that are now delivered by public supported schools . . . can be provided and are being provided by other means, which turns out to be more economical for the student."

Mr. Anastasio, in turn, offered the view that programs like "Sesame Street" and "The Electric Company" provided instruction to children, including skill development at a low cost.

> I think there will be more opportunity in the future for people to become responsible for their own education and that of their children. I am not sure I like it right now. What it may be leading to is a further split between the disadvantaged of our country and the less disadvantaged. We have the case in a lot of major metropolitan areas, where school boards are forced to make cuts in programs they offer, and the impact on the community is devastating in the sense that people who cannot afford to procure the services being cut do without them. Others who can afford it go outside to the private sector and are gaining that much more advantage or opportunity. I am also entirely confident that the private sector people who provide the services are being motivated by all the same things I would be motivated by if I were standing in front of a classroom. They might not be willing to take all of the care they ought to be taking in providing alternate forms of instruction.

In furnishing yet another perspective, Dr. Mosmann suggested that "we also focus our attention on the people who are making the decisions:"

> In the case of the marketing concept, the people who are making the decisions in the schools are using some kind of information. We must look at what their problems are and the way they make decisions. We must find ways to help them.
>
> Insofar as it is not the educational establishment that makes decisions about what mode of instruction would be used, the student himself or herself will make it. The person who would like to speak French has an alternative of going to the community college or plugging into the TV set at home. That person is making an evaluative decision.

Describing himself as probably representing "the type of ignorance that makes some of these decisions," Howard Greis—a lay member of the Massachusetts State Board of Education—lamented the difficulties faced by decisionmakers: the jargon and the length of time required for such studies, for example. He cited the "business of mastery education:"

> I have talked to a number of parents about that, and they say: "What, isn't that what we are always doing?" Or at least, "Isn't that what we should have been doing?" You know, we ought to teach the person what we are trying to teach him; and if he does not learn it, we should give him some help in the classroom. This is typical. The same holds true recently of a whole series of reports which say that, in essence, the main thing that makes success in basics is successful time on task. So a parent says to me, "Well, practice makes perfect, doesn't it?" I think that part of the problem here is that the public is making a decision for you right now because they sense the microcomputer represents an ability to do a lot of these very simple-minded things, and when they hear about longitudinal studies, and all that sort of thing, they throw up their hands and say "more educational jargon."

The public saw educational expenditures rise from 3.7 to 7.5 of the GNP without appreciable improvements and said "Hey, what's happening here." The microcomputer is seen as "something new, some possible change in direction," and has become a "primary motivating force" in the new look at the potential of information technology. He then cautioned his listeners: "* * * you're all going to be way behind the public unless we find some better way of approaching the whole issue."

The Chairman agreed that there is a "very important point" here which needs to be made:

> * * * in the most positive way, and that is that of expanding the horizon of educators rather than contracting their horizons. For example, if we are going to make the best use of this technology, and a lot of it is going to be done in the home, the office, or the community, maybe we ought to think about how to impact these factors so as to get the best educational product out of it rather than just letting it go by accident or by the pressures of the private sector to market it as effectively as possible.

Reference was made by the next questioner, William Greenup of the U.S. Marine Corps Education Center in Quantico, Va., to certain questions raised by Dr. Mosmann in his formal remarks. Among those were:

* * * how much computing does a student need?

* * * what kind of computing?

* * * What can the institution do to encourage students and teachers to make effective use of it?

* * * how does an institution go about answering these questions on their own?

Mr. Greenup then wondered if either Dr. Mosmann or Mr. Anastasio could recommend "any useful models that exist that would enable institutions to identify potentially high payoff areas for computer-based instruction?" After the latter panelist mentioned as "most successful" the ones dealing with skill development or refinement or those concerned with "straightforward training situations"—these were "as opposed to more advanced conceptual instruction"—Dr. Mosmann suggested that his handbook might be useful.

In reference to comments about "the potential of the delivery of educational services to the home via the new technological means," an unidentified attendee asked these two questions:

> * * * what do you think should be the role of Congress and the Federal Government in both facilitating development of this kind of service, assuring that as it develops, we will not be further disadvantaging those who have not benefited fully from our existing educational system? In other words, how can we try to prevent the gap between the educational haves and have-nots from widening as a result of these technologies?

Representative Brown replied that "the role of the Congress in answering that question is not at all clear to the Congress. We need as much education as any other important community playing a role in this technological revolution." He went on to say that this very matter "is part of our purpose here today." One approach will involve trying to bring about "some structure of regulatory order as to the role of the various factors in the market place . . . the schools, the commercial media, other public organizations." Shifting his emphasis, the Chairman addressed the "fundamental problem that you raise of inequity in society and inequitable access to information resources" and noted that a "range of initiatives" will be required.

Reminding the hearing participants that "economic inequalities" had not prevented even those in the poorest strata from having a television set, he hoped that "we can continue along this path by making the demand for information resources and learning opportunities as attractive as with access to 'All in the Family.'" And finally, Representative Brown returned to the fundamental dilemma of motivating people to want to acquire information and knowledge in order to fulfill their societal roles.

> That question goes far beyond the question of this technology. I don't think that the course is going to be the Federal Government deciding that everybody should have a computer and subsidizing poor people to acquire computers. We have done similar things in limited cases; for example, we are spending a quarter of a billion dollars a year to make sure people don't freeze to death because of the high cost of heating oil, but I don't think we are going to put computers or learning technologies in that same category. I think we will have to address the more fundamental problem of inequality in society. That is about the best answer I can give to that very profound question.

On this note, the final phase of the formal hearing was completed, and preparations were undertaken for the afternoon session when the reports from the various discussion groups of the workshop would be transmitted to the Subcommittees' members.

VII. HIGHLIGHTS AND COMMENTARY: TECHNICAL WORKSHOP ON INFORMATION TECHNOLOGY IN EDUCATION, APRIL 1980

In his prefacing remarks upon opening the second hearing on Information Technology in Education, Representative George E. Brown, Jr. had charged the workshop participants to help "derive a consensus which will direct us toward the appropriate goals and policies." As an integral, contributory component of the overall hearing, the technical workshop would allow an airing of the "expertise and perspectives" of the public and private sector attendees, which would in turn assist the sponsoring Subcommittees "to devise priorities necessary to achieve educational objectives."

The six discussion groups, as noted earlier, were composed of volunteer participants from universities, libraries, foundations, corporations, associations, and governmental entities, with this range of foci:

Group 1—Elementary and Secondary Education.
Group 2—Post-Secondary Education.
Group 3—Adult Education.
Group 4—Special Education.
Group 5—Development of Information Technology.
Group 6—Public Planning for Education in the Information Society.

On April 3, the summary oral reports of each group were presented to the Subcommittees. The chairman of Group 1 was Dr. George H. Litman, Staff Assistant for the Bureau of Computer-Assisted Education, Chicago Board of Education. After noting that information technology fulfills two major roles in public education today—as the "object of instruction" and also as the "tool of instruction"—he enumerated certain concerns which may arise in connection with each.

As regards the former area, he equated the "object of instruction" role with computer literacy or computer "comfortableness." Subsequent to declaring that "every citizen should understand the general principles of information science," the group spokesman stated that computer education at the elementary and secondary levels is "desirable and feasible," but that certain concerns must be recognized:

> * * * how are we to expose students equally to such technology * * * information and communications technology * * * continue[s] to shatter the concept of the classroom as the center of learning experience.
>
> * * * how are we to provide the necessary training and retraining of teachers of elementary and secondary schools to permit them to understand and use the new available technologies * * * During the formal learning periods of the majority of teachers these modern information technologies did not exist and no effort has been made to bring this knowledge to them.

> * * * how are we to provide the training and retraining necessary to permit enlightened decisionmaking by administrators and "para-educators"—those people involved in education but not directly in schools, including members of this subcommittee.

A more complex set of "issues of concern" was identified by Dr. Litman in connection with technology as a "tool of instruction," by which he meant CAI, whether "viewed as a network with a large-scale computer system with large number of terminals or as individual microprocessors:"

> Reducing the further separation and polarization of the population because of the new technology * * * This technology * * * generally [serves] the affluent, the "haves," the suburban school. It has not made an impact on the poor, the "have-nots," the city school.
>
> * * * the quality of the curriculum * * * hundreds, maybe thousands, of CAI lessons * * * have not been validated * * * There exist almost no curriculums, that is, groups of related courses.
>
> * * * information about information technology. The public needs to be informed of the impact of information technology in the schools and in their own world.
>
> * * * the private sector already has a foothold in all the school systems of this country, and we need to move quickly to prevent a catastrophic purchase of misunderstood, misused and misrepresented devices and associated courseware.

Dr. Litman said that while his group had few specific recommendations, it did "urge the Federal Government to encourage the incorporation of contemporary information systems in public education." Four "suggestions" were then enumerated for the Subcommittees' consideration:

> 1. Grants, categorical grants to help narrow the differences between the "haves" and "have-nots" in terms of acquiring hardware and softwear. In addition, these grants could include requirements that would make subtle but important changes in the direction that the growth of information technology is now taking. These subtleties could be clauses requiring validation data of courseware or curriculum software, evaluation, and description of previous uses of such software, cost effectiveness data, and so on.
>
> 2. Increased NSF, ESEA, and other grants specifically aimed at providing teacher and administrative preservice and inservice, training, and retraining in the areas mentioned.
>
> 3. Federal support of a network of State and local agencies—some already exist—that would serve a role in evaluation, validation, and dissemination of information regarding hardware and software in this new and ever-growing field.
>
> 4. A tax incentive program to encourage the role of private institutions in the application of information technology in public education. Many possibilities exist such as the ex-

change of personnel with school systems, sharing of equipment, loan of personnel, and so on.

He noted that these four recommendations are "economically conservative, philosophically realistic, and in line with the Federal Government's past role in education." And furthermore, he said, "They would require no significant changes in the direction of Federal involvement in education nor would they require the adoption of radically new legislation."

Reporting for Group 2 (Post-Secondary Education) was Dr. Karl L. Zinn, a research scientist at the Center for Research on Learning and Teaching at the University of Michigan. Stressing that he would like to draw attention to "the personal nature of the benefits—or the negative side effects—of increased use of information technology in education," he affirmed a belief that:

> The measure of success of new programs for information technology in education should be taken not just in terms of dollars, or units of equipment, or numbers of students exposed to computers, or the quality of the curriculum materials. We have to consider the impact on people and on their lives, the secondary effects as well as the intended primary ones, and the negative as well as the positive.

In summarizing the formal report of the group, he announced that he would draw upon those written recommendations and his own experiences.

> It need not be stressed that the general public recognizes the explosion in technology and information as a problem. But we in higher education must take as a challenge and an opportunity the need to guide these developments, and to help integrate them into the domain of education and training throughout society. The new technologies introduce qualitative changes in our intellectual lives which will have widespread impact on society and individuals.

Dr. Zinn went ahead to talk about the satisfaction derived by students who had discovered "the wealth of information and leverage of information processing available to them through new technologies—students who are taking new initiative for their own learning." He related to his listeners the fact that Group 2 had expressed "unambiguously the need to provide access to underrepresented groups: social, economic, and ethnic minorities, women, handicapped; and the elderly." Illustrative of an opportunity which was made available to one student in a class taught by Dr. Zinn in Grand Rapids:

> He came in a wheelchair without voice or keyboard to communicate with me. He now carries on his chair a personal computer which provides spoken voice and text display, and it allows him to enter, organize, and retrieve information as he needs it for communication, study, and professional work. Already a good computer programer, some day he will be an excellent system designer.
>
> Jim carries his personal computer with him on his battery-powered wheelchair. So his computer also needs to take its

power from the battery and be rugged enough to handle the range of temperatures and moisture wherever he goes. It needs a large memory to store the vocabulary of words and phrases he would like to speak, as well as computer programs for personal convenience, and information to have at hand.

A voice synthesizer has been added to the computer so that whatever Jim wants to say can be spoken by the machine. He assembles words and phrases, directing his computer with a foot pedal, since that's the part of his body over which he has good control. The text of what he wants to say appears on a small screen mounted on the arm of his wheelchair. When it's right, and when he has the attention of his listener, he directs the computer to speak, at a normal rate, the entire utterance. It might be just "How are you?" or it could be the speech for a national conference on communication aids for handicappers.

Jim has a fine mind, and his brain works well in all respects except motor control. He is a student at Grand Rapids Junior College and plans to attend Michigan State University next fall. One of his current interests is design of information systems. Probably he'll have a chance to work at the artificial language lab at MSU, the same group that helped him gain a voice.

An important point which needs to be made in connection with this example, Dr. Zinn said, is that "the same technology that helps us communicate for recreation, or for business, may be a necessity for someone who has been denied some basic medium of communication, such as speech."

In reinforcement of comments made both during formal hearings and as part of other workshop findings, he underscored the fact that:

> Computing technology is advancing rapidly, and the industry is pushing new products too fast for people to master them. . . . The technology and its marketing far exceed the available programs for faculty development.

Alluding to earlier statements by Dr. Heuston and Dr. Johnson, this group spokesman iterated that "Federal programs are needed to encourage development and validation of exemplary curriculums, software and systems."

Another reported focal area dealt with the dissemination of information and "ideas about technology in education," with especial emphasis on "the need for transfer between disciplines and throughout communities of researchers, and from the laboratories to the classrooms." Dr. Zinn then related how he had used his portable terminal the previous evening, in his hotel room, to obtain comment on background material for his working group.

In closing, Dr. Zinn urged that the recommendations of prior hearings (1977, 1978) and study groups (published in 1966, 1967, 1970, 1972, 1975) should be reviewed.

> Useful information and good advice have been accumulating for over 15 years; we are developing some consensus on what needs to be done. Clearly, it is time for action.

And this "action," he stated, should be beyond simply that to be carried out by Congress or the executive branch.

> Each of us should assume some responsibility for carrying the important ideas back to our own communities and into our professional circles where they will do much good for education through the wise application of information technology.

The next report, reflecting the deliberations of Group 6 (Public Planning for Education in the Information Society), was presented by Joseph Becker, President, Becker and Hayes. He commenced by describing how the convergence of three technologies—computers, communications, and audio-video—is "creating a new information environment in our country affecting not only our educational systems but also other aspects of our national life."

Mr. Becker then highlighted a few random but key points which had emerged during the two days of discussion, and which his group felt were significant:

> The role of the teacher is changing . . . an increasing share of the GNP is being devoted to the production of knowledge . . . Change is occurring so fast today that we hardly have time to plan . . . information technology is the handmaiden of productivity. . . . Information isn't coming, it's already here . . . it will soon be democratized.

As a result of their dialogue, the members of Group 6 concluded that information technology "is apt to touch people" in three ways:

> First, it affects the way citizens access information resources, whether by networks or other ways, it implies greater control over content and quality. Adopting unwise policies now could cause great inequities in terms of who is able to access what in our society.
>
> Second, as far as the technology is concerned, it brings information directly into the home in an interactive sense. Every den in a house is a potential home information center. Personalized TV instruction may very well bypass traditional school methods as individuals in the home choose the things they want to learn.
>
> Third, technology equates with microprocessors. The semiconductor chip can develop significant educational abilities. Something new in education is coming along, we don't know what, but we have a feeling it relates in some way to the television set, the home, and intelligent terminals.

The group's concern centered, he said, on introducing information technology into education in a responsible way. In addition, certain problems must be faced lest "we risk losing the technological advantage we now possess . . . we are in danger of introducing incompatible systems of machines, rather than systems of high educational quality." Mr. Becker affirmed his group's belief that:

> Information technology is not just another Government problem. It is a national phenomenon. One that is multidimensional and cuts across all aspects of our Government and national life.

A series of important questions then was posed, even though it was recognized that many had been raised on previous occasions:

> The application of information technology to education raises difficult questions: Will emerging systems be compatible? Will users be charged for the information they access and use? What is the role of the Federal Government? Are community research centers to be encouraged? In what ways will the introduction of new information technology change the traditional structure of American education?

Several issues were identified—in regard to the need for a national policy—which warrant congressional attention:

> 1. * * * creating a nationwide network * * * a focal point to coordinate and facilitate the deployment of educational information.
>
> 2. * * * defining or planning the Federal role * * * to designate an entity in Government and assign it responsibility for designing and developing policy on the utilization of information technology in education.
>
> 3. * * * equalizing access to knowledge * * * regardless of his or her geographic location or economic circumstances * * * We need to apply the same legal and statutory language which has governed the development of public education in the United States to information technology.
>
> 4. * * * protecting intellectual property and encouraging the private sector investment * * * devise means for compensating authors and publishers * * * enunciate principles promoting the creation of educational products and services of high quality.
>
> 5. * * * standards * * * involuntary standards [are needed] to guide the compatible development of technology without inhibiting innovation.
>
> 6. * * * consolidating information about information technology * * * establish some kind of clearinghouse.

Turning to the "initiatives" which Congress should consider, Group 6 had five specific recommendations:

> • * * * that the Congress create a permanent national commission on information technology.
>
> • * * * the Congress advise the Secretary of Education of the potential significance of information technology to education and that funds be provided for relevant studies, demonstrations, clearinghouses.
>
> • * * * a person experienced in the field of education technology be appointed to serve on the Intergovernmental Advisory Council of Education.
>
> • * * * that new legislation be drafted that will enable libraries to form a national network of knowledge.
>
> • * * * that the Congress designate a small group * * * to meet again in 3 months time * * * to report on progress and provide whatever input would be beneficial to the Congress.

Reporting for Group 4 (Special Education) was Dr. Donald V. Torr, Assistant Vice President for Educational Resources at Gallaudet College in Washington, D.C., whose initial commentary focused on concerns raised by some of the presentations which addressed computer-assisted instruction, which might be inferred to be "the answer to the educational problems we face today."

> We agree that CAI can serve a very useful function in education, but urge that it be seen as one tool among many which can be used by the teacher. There are some tasks which can well be assigned to the computer; however, it is unlikely, for example, to serve as a good role model or to help a student develop successful social skills. We also questioned one element of cost. While hardware costs are falling the cost for the development of instructional software is not. Lack of software has been the major problem to date. It is not clear that a funding base for significant instructional software development exists today.

Next, he sought to differentiate meaningfully between the terms "information technology" and "educational technology":

> To me educational technology is any technology arising from basic research in the physical and behavioral sciences which can be used to contribute to the solution of an educational problem. I see information technology as any technology which can be employed to effect the emission, transmission, storage, processing, or reception of information. Much information technology can be employed as educational technology; this is especially true when dealing with special education. In dealing with educational problems, however, we should not consider information technology as providing the full solution set.

Dr. Torr then turned to the issues identified by his group, which included:

1. * * * the need to insure that as new technology becomes available the needs and rights of handicapped individuals are not forgotten.
2. * * * individuals need to understand that technology is not all powerful in spite of the fact that "technology" made it possible for men to land upon the moon and return. It is not possible today to automatically encode continuous speech, for example.
3. * * * while the needs of special education for the application of information technology and other technologies are great, the market is too small to make the area commercially attractive.
4. * * * the need for a noncommercial centralized consulting base of persons who are knowledgeable of information technology and who can quickly assist problem solvers who do not have the time to search for all relevant technology.
5. * * * the need for validation data in the promotional literature of equipment manufacturers. Data should be provided which specifies the conditions under which the equipment has been tested and shown to do what the manufacturer claims.

In accordance with its instructions from the seminar's organizers, Group 4 also had prepared a set of recommendations:

- * * * that special educators themselves make it a practice to involve equipment manufacturers or software developers as early as possible in their efforts to develop solutions to special education problems.
- * * * that special educators meet and agree upon problem statements which can be used to stimulate problems solvers who know the technology available.
- With respect to the development of initiatives to encourage interest in the small special education market * * * that the explorations which have been initiated by Congressman Brown be encouraged * * * meetings which have been bringing together members of the public and private sectors to discuss such matters as: financing incentives, patents and licensing, market research, and standardization * * * the unique need for incentives associated with development for handicapped individuals [should] be emphasized in those discussions.
- * * * that the Subcommittee explore with the Department of Education the need to establish an independent base for technical support in the field of information technology.
- * * * that the private sector devote time to the development of increasingly sophisticated information processing techniques for CAI to provide more than the "information presentation, example, test, and branch" paradigm.

Dr. Torr's final appeal was that a focused approach must be taken in coping with our many problems, drawing upon the "immense resource of knowledgeable persons" who are available, and that these problems transcend those limited to information technology and its applications.

Dr. Milan Wall, Executive Vice President at the University of Mid-America, was the reporting chairman for Group 3, on Adult Education, who commenced by articulating a "statement of belief":

> * * * that the pace of change in our society—including increased rates of knowledge and more efficient means for disseminating that knowledge—has increased dramatically, and it is likely to increase in the foreseeable future.

This will require, he continued, that both government and the private sector review the "current model of education." Such a review will lead to the conclusion that on-going societal changes require a "reconceptualization" of the educational model so that continuing education for adults, whether formal or informal, is enhanced. Next, he urged Congress to "carefully consider earmarking or redirecting funds for the purpose of supporting efforts to design and implement technology" in support of adult education in both "formal and informal settings."

The focus then shifted to the identification of a series of issues which the working group on adult education felt was vital:

Issue No. 1: Relatively little is known about how adults learn, why they are motivated to learn, and how to motivate them to overcome personal barriers to certain kinds of learning.

Issue No. 2: Insufficient financing is available for development of educational software and acquisition of hardware for adult education.

Issue No. 3: Barriers exist to availability of financial aid for adult learning in nontraditional educational programs.

Issue No. 4: Insufficient standardization of hardware and software specifications makes usage difficult across product lines.

Issue No. 5: Telecommunications agencies do not pay adequate attention to educational users.

Issue No. 6: Government regulation and practices tend to favor traditional curriculums.

And issue No. 7: Government attempts to enhance equity for disadvantaged younger students have not been very successful, and we believe there is a danger the same record may extend to this segment of our older population.

Dr. Wall then transitioned into the list of 10 recommendations emanating from his group:

Recommendation No. 1 deals with our knowledge about how adults learn and related issues, and our recommendation is that various Government agencies that deal with adult learning considerations, among them USDA, NIE and the military, should direct more resources to research efforts to find out how adults learn, and why they are motivated to learn.

Recommendation No. 2: We proposed studying the feasibility of the creation of a tax on certain technologies in order to support development of such technologies for the public benefit.

Recommendation No. 3: Barriers that exist to the availability of financial aid should be removed so that adult learners may benefit.

Recommendation No. 4: We believe that the Federal Government should encourage compatible hardware and software systems to further broaden the applications of those systems.

Recommendation No. 5: The Federal Government should support development of programs for increasing adult competencies in the use of informational technologies of all kinds.

Recommendation No. 6: Funding should be made available to public community learning resource centers, such as public libraries, for acquisition of hardware and software for the use by the public.

Recommendation No. 7: An increasing amount of the $14 billion currently spent for adult education should be redirected to development and use of new technologies in order to achieve objectives in the adult education arena.

Second, a part of that recommendation, we believe increasing amounts of information technology and telecommunications expenditures should be directed toward adult education.

Recommendation No. 8: Current Government-supported delivery systems for informational and educational purposes, and we cite as one example the extension service, should be encouraged to make more uses of new technologies.

Recommendation No. 9: Preferential telecommunication rates should be established for educational purposes.

Recommendation No. 10: Stated more eloquently by Mr. Becker who might have been listening in on our discussions as well—copyright considerations should encourage widespread dissemination of educational materials.

The last of the six discussion group findings was presented by Dr. Richard Ballard, Manager of the Educational Program Information Center at the Apple Educational Foundation. Group 5, with an assignment to look at the "Development of Information Technology," was comprised of people concerned with the development of materials. Noting that priorities had changed over the last decade, its spokesman said that:

> * * * there is less of a concern for presenting a vision of the kind of hardware we ought to have, and much more concern in this coming decade for the materials that are going to be developed. . . . The 1980's, we think, are going to be a decade of development.

He continued by pointing out that private investors now can see "real markets of tens of thousands and hundreds of thousands of units . . . and we are going to see investments flood in in areas where there are markets."

The very nature of Group 5 elicited comment from Dr. Ballard:

> Our own group was perhaps the largest of the discussion groups, indicating the interest that people have in development at this time, and it represented educators and it also represented business people, people in training and in a lot of areas. That was very different from the kinds of conferences held in the past. There were a lot of representatives from corporations. Some of them are new, some of them have quite a bit of experience. Some of them are tinkering at the outside of this field, and others have very substantial commitments and powers within their organizations. All of them are making substantial career commitments—all of them are taking risks in getting involved in development at this early stage.

In his view, this is "a good time to look at public issues and private solutions." Several issues worth considering were then identified:

> * * * emotional issues like protection * * * risking their genius and their life's work and millions of dollars of investors' money * * * want copyrights and patents to really mean something * * * are producing a new kind of property, an intellectual property.
>
> This courseware they are developing is extremely valuable * * * there is ample proof in the literature that it is effective * * * we are asking [Congress] to fix the problems and to do some things that will trigger self-sustaining efforts by other people * * * [such as] royalty restrictions [which make it] almost impossible for Government-sponsored projects to attain any size and to cooperate in any way with industry.

Three other issues where congressional action was deemed vital were described in these words:

- We would like Congress to pick out certain project areas and funding areas, where it's fairly clear from the small markets and the importance of the projects that no one is going to get rich * * * like them to remove all restrictions on the author's future collection of royalties.
- We think there are places where Congress can stimulate the market with fairly small expenditures * * * that would be only of a limited duration * * * just providing equipment, technological equipment like computers and video units.
- Another thing Congress can do, and has done in the past * * * is to assign some percentages * * * to be spent on projects of advanced technology.

Returning to other focal areas, Dr. Ballard informed his listeners that:

> One of the biggest issues today is the size of the development projects going on. Right now if you look around in video or in computers, you will find a lot of small programs, and they are not really very helpful * * * We would like to see them take the same money—not more money, the same money—and take at least part of it to divide up into some large projects * * * that can achieve curricular importance, that will put out enough in the way of materials that they will go into the classroom and have real impact.

In essence, Dr. Ballard was asking, for his group, that some money be placed in "bigger pots," and that the Government authorize "some risks right now." He then detailed the interwoven problems and alternative approaches to their solution:

> Why doesn't this happen? Invariably, when anybody tries to make a proposal and put together a program, a plan for cooperation in sharing resources and profits, there just aren't the regulations and the contractual methods for doing this. This whole thing snags on the fact that there isn't something written to allow this, so we think that a great deal would come out of looking very closely at some regulations and creating, in law and in policy, some things that would make this happen.
>
> Another thing is that the Government is both a large purchaser of instructional technology and a source of grants that make other people purchasers. We would like them to put language in those grants and in their purchasing that would keep people who are excited about this field buying things just out of that excitement. As buyers, we would like to see requirements put up upon manufacturers that they not only provide some minimal amounts of software, but they provide lists of software suppliers to their hardware, and that they provide materials and actually train the teachers and end users in this. Those things could be made into purchase packages in military uses, in training areas, and in education.

Next, he indicated the critical need for "authors" in this field. This could be met in part, he suggested, by bringing "academics into publishing and manufacturing situations, and * * * programers and people out of the industries and into the schools." Other areas of potential action:

> * * * need to be some centers for distributing information in understandable forms, to compare equipment in terms that are meaningful to school administrators.
> * * * need information that lists software, and tells you where it is available.
> * * * important to have information on product performance, particularly as software comes in from a great many different manufacturers.
> * * * like to see product performance evaluated, not so much in the way of standards but in the way of certification * * * Is the cost of performance what the manufacturer claims it to be?
> * * * like to see some efforts to encourage manufacturers to broaden their assumptions about who is going to use their equipment.

The thrust of Dr. Ballard's final remarks touched on "learning model research," which he felt was the result of "manufacturers and authors * * * going out and putting the stuff together by the seats of their pants." What is needed, he noted, was "guidance to tell what paradigms and strategies are effective for this medium and most likely to produce learning." And then a parting admonition:

> Right now we are asking for help from Congress * * * and if we can't get that help then we think it would be wise for Congress to at least get out of the way.

Representative Brown, in acknowledgement, noted that Congress is working in several of the areas raised by speakers: copyrights, patents, and "improvement of the public/private cooperation mechanisms."

In regard to the matter of certification by software manufacturers, Ken Komoski of the EPIE Institute recalled that he had "testified before this committee regarding the need for this" and subsequently been involved with legislation requiring this in the State of California. He continued, saying that Florida had passed appropriate legislation, which in no way had been implemented by the State education agencies. Thus, this is an instance of having a mechanism in being "and all we need to do is to have it applied." Dr. Ballard, in response, agreed that there must be reliable, responsive "valuation procedures." We do need not just a law," he said, "but organizations coming forward with methodologies for evaluating these programs so manufacturers can test them."

Representative Brown, in underscoring a point made earlier, stressed the importance of looking at "the total of information technology." The comment about standards and methods of evaluation caused him to "think about the global economic importance of what is going on":

> One of the things that we need to be concerned about is the United States market position. We are not going to be mar-

keting our own particular brand of software or courseware, for example, to meet the information needs of the rest of the world. They will want to produce their own that is compatibility with their culture and their needs. What we are going to sell them probably is some hardware and maybe some of the hardware types of software.

When it comes to most of the software things, we are going to be selling them procedures and methods of creating what will be suitable for their situation and their methods of evaluation. We really need to step back in our society as we go through this period and not only do it, and test it, but analyze how we did it, how we tested it, and how that can be applied to markets in other parts of the world, because that is what they are going to want in order to go through the transition a lot faster than we have gone through it.

The Chairman then cited, as an example of this pattern of events, the recent U.S. dealings with The People's Republic of China, which wants a satellite system and several thousand ground stations, rather than putting in a hard-wired communications system:

They will skip the business of wiring China and go directly to satellites. How do we take advantage of their needs in a way that meets both of our requirements? That it helps both of us, is the point that I worry about a great deal because in the long run that's what we will have to do.

Representative Brown then introduced Robert L. Chartrand, the Senior Specialist in Information Policy and Technology for the Congressional Research Service (Library of Congress), who had worked closely with the staffs of the two Subcommittees in organizing the workshop.

In his initial commentary, Mr. Chartrand reminded the audience that Representative Brown had provided a two-fold objective for the seminar:

To enhance the awareness of Congress, the executive branch, and the private and public sectors of (1) the potential educational benefits of new information and telecommunications technologies, and (2) the possible social and economic impacts resulting from the widespread use of these technologies in the educational process.

A historical note was then sounded, as he talked about the milestone panel sessions held in 1970 under the sponsorship of the then House Committee on Science and Astronautics, which had explored the topic of the "Management of Information and Knowledge." [148]

Among the several dimensions of that topic was the role of information technology, and germane to our present seminar, coming 10 years later, was the emphasis by McGeorge Bundy, at that time serving as president of The Ford Foundation, on understanding the "boundaries" of technology supported systems, including both the benefits and limitations of the new

[148] U.S. Congress. Management of Information and Knowledge 1970.

tools and techniques. It seems to me the applicability of his comments about the advantages of using computers to assimilate and integrate selected data so that the user can most fully utilize the products, and his reminder that the "direct relationship between the quality of raw data elements or input and the value of knowledge outputs" must always be understood. I think these observations still merit our attention.

Mr. Chartrand then acknowledged the contribution of the workshop participants: "those who function as conceptualists, as catalysts between the subject areas and the technology which can process and display the desired information, the teachers, the technological innovators, and what we now call the gatekeepers of information." Through the interest and involvement of these diverse talents, the two sponsoring Subcommittees will receive an exposition of:

> * * * the key issues related to maximizing the positive impact of information technology in the educational milieu; * * * those identifiable initiatives which Congress, the Federal executive branch, and the private sector may undertake to enhance understanding and support of this vital area.

These hearings and workshop sections represent a "beginning," in his opinion:

> * * * which will enable cognizant congressional groups to evolve new perceptions and legislative approaches that can result in improved planning and programs. Needless to say, your sustained support is extremely important as the Subcommittee on Science, Research, and Technology and the Subcommittee on Select Education continue to address the several facets of this focal area: economic, technical, cultural, and legislative.

The culmination of Mr. Chartrand's remarks took the form of a quotation—attributed to Thomas Jefferson—which touched on "what we face today, and what we should keep in mind:"[149]

> Laws and institutions must go hand in hand with the progress of the human mind. As that becomes more developed, more enlightened, as new discoveries are made, new truths disclosed, and manners and opinions change with the change of circumstances, institutions must advance also and keep pace with the times.

So it was in that vein that the hearing and workshop participants, responding within the democratic process, reflected a determination to constructively integrate information technology within the educational framework, while concurrently reflecting the philosophy expressed in an ancient proverb which declared that "where there is no vision, the people perish."[150]

[149] 115 Cong. Rec. 102.
[150] Bible. O.T., Proverbs, XXIX, 18.

APPENDIX 1

Matrix Showing Key Congressional Activities (1969-1980)

Year	Key Legislative Initiatives	Cognizant Congressional Committee/Subcommittee	Chairman	Focal Legislation	Pertinent Public Laws	Related Reports
1969	Hearings on Needs of Elementary and Secondary Education for the Seventies	H. Comte. on Education and Labor/Gen. Subc. on Education	Rep. Roman C. Pucinski	H.R. 517 H.R. 776 H.R. 9866 H.R. 10833 H.R. 11546		"Achieving Nationwide Educational Excellence" (by Lora Keyearling)
1970	Hearing on Educational Technology Act of 1969	H. Comte. on Education and Labor/Sel. Subc. on Education	Rep. John Brademas	H.R. 8838	P.L. 91-61	Run, Computer, Run (by Anthony Oettinger) "To Improve Learning" (McMurrin Commission)
1970	Hearings on Higher Education Amendments of 1970	S. Comte. on Labor and Public Welfare/Subc. on Education	Sen. Claiborne Pell	S. 3474	P.L. 91-117 P.L. 91-230 P.L. 91-345	"A Compendium of Policy Papers" on Elementary/Secondary Needs for 1970's
1970	Panel on Science & Technology sessions on The Management of Information and Knowledge	H. Comte. on Science and Astronautics/Panel on Science and Tech.	Rep. George P. Miller			"The Management of Information and Knowledge." Papers prepared for the eleventh meeting of the Panel on Science and Technology
1970	Hearings on Foreign Policy Implications of Satellite Communications	H. Comte. on Foreign Affairs/Subc. on National Security Policy and Scientific Developments	Rep. Clement J. Zablocki			
1971	Hearings to Establish a National Institute of Education	H. Comte. on Education and Labor/Sel. Subc. on Education	Rep. John Brademas	H.R. 33 H.R. 3606		
1972	Hearings on HEW and Related Agencies Appropriate for FY 1973	S. Comte. on Appropriations/Subc. on Appropriations	Sen. Warren C Magnuson	H.R. 15417	P.L. 92-318	The Emerging Technology: Instructional Uses of the Computer in Higher Education (By Roger Levien)
1972	Hearings on Educational Technology	H. Comte. on Education and Labor/Sel. Subc. on Education	Rep. John Brademas	H.R. 4916 H.R. 16572	P.L. 92-419	"Reappraisal of the Educational Technology Industry" (conference proceedings, U. of Chicago, 1969)
1973	Hearings on Education for the Handicapped, 1973	S. Comte. on Labor and Public Welfare/Subc. on Handicapped	Sen. Jennings Randolph	S. 6 S. 34 S. 808 S. 896	P.L. 93-380 P.L. 93-568	"Computer-Assisted Instruction for Dispersed Populations: System Cost Models" by John Ball and Dean Jamison

Year	Key Legislative Initiatives	Cognizant Congressional Committee/Subcommittee	Chairman	Focal Legislation	Pertinent Public Laws	Related Reports
1975	Hearings on Telecommunications Facilities and Demonstration Act of 1975	H. Comte. on Interstate and Foreign Commerce/ Subc. on Communications	Rep. Torbert H. MacDonald	H.R. 4565	P.L. 94-142 P.L. 94-309 P.L. 94-482	
1977	Hearing on Rural Telecommunications	S. Comte. on Commerce, Science, and Transportation/Subc. on Communications	Sen. Ernest F. Hollings			"The Feasibility and Value of Broadband Communications in Rural Areas" (OTA report)
1977	Computers and the Learning Society	H. Comte. on Science and Technology/Subc. on Domestic and International Scientific Planning, Analysis and Cooperation	Rep. James H. Scheuer		P.L. 95-561	"Into the Information Age." A Perspective for Federal Action on Information. (Arthur D. Little)
1979	Hearing on Information and Communications Technologies Appropriate in Education	H. Comte. on Science and Technology/Subc. on Science, Research and Technology	Rep. George E. Brown, Jr.	H.R. 4326		"Technology in Science Education. The Next Ten Years." (National Science Foundation)
1980	Joint Hearings on Information Technology in Education	H. Comte. on Science and Technology/ Subc. on Science, Research and Technology, and H. Comte. on Education and Labor/ H. Subc. on Select Education	Rep. George E. Brown, Jr. and Rep. Paul Simon		P.L. 96-88	"Needs of Elementary & Secondary Education in the 1980's. A Compendium of Policy Papers" "Application of Technology to Handicapped Individuals: Process, Problems and Progress" (CRS report)

APPENDIX 2

Public Laws with Provisions re Information Technology in Education

Congress	Public Law Number	Short Title
85th 1957-1958	P.L. 85-864	National Defense Education Act
	P.L. 85-905	Instructional Media for Handicapped Children Act
87th 1961-1962	P.L. 87-447	Communications Act of 1934, Amendment
88th 1963-1964	P.L. 88-164	Mental Retardation Facilities and Community Mental Health Act
	P.L. 88-204	Higher Education Facilities Act
	P.L. 88-210	Vocational Education Act
	P.L. 88-269	Library Services Act Amendment
89th 1965-1966	P.L. 89-10	Elementary and Secondary Education Act
	P.L. 89-313	School Construction Assistance in Major Disaster Areas
	P.L. 89-329	Higher Education Act
1966	P.L. 89-511	Library Services and Construction Act
1967	P.L. 89-694	Model Secondary School Act
	P.L. 89-750	Elementary and Secondary Education Amendments of 1966
90th 1967-1968	P.L. 90-35	Education Professions Development Act
	P.L. 90-129	Public Broadcasting Act of 1967
	P.L. 90-247	Elementary and Secondary Education Act Amendments of 1967

Congress	Public Law Number	Short Title
	P.L. 90-575	Higher Education Amendments of 1968
	P.L. 90-576	Vocational Education Amendments of 1968
91st 1969-1970	P.L. 91-61	National Center Educational Media and Materials for the Handicapped Act
	P.L. 91-117	To Extend the Higher Education Act of 1965 and to Extend Vocational Act of 1963
	P.L. 91-230	Elementary and Secondary Education Assistance Programs Extension
1970	P.L. 91-345	An Act to Establish a National Commission on Libraries and Information Science
92nd 1971-1972	P.L. 92-318	Emergency School Aid Act
	P.L. 92-419	Rural Development Act of 1972
93rd 1973-1974	P.L. 93-380	Elementary and Secondary Education Act Amendments of 1974
	P.L. 93-568	White House Conference on Library and Information Services Act
94th 1975-1976	P.L. 94-142	Education for All Handicapped Children Act of 1975
	P.L. 94-309	Educational Broadcasting Facilities and Telecommunications Demonstration Act of 1976
	P.L. 94-482	Education Amendments of 1976--Teacher Corp and Training Program
95th 1977-1978	P.L. 95-561	Elementary and Secondary Education Act Amendments of 1978
96th 1979-1980	P.L. 96-88	Department of Education Organization Act

APPENDIX 3

Can Television Really Teach? 1/

PRESCHOOLERS ACROSS THE NATION WILL PROVIDE SOME ANSWERS THIS FALL AS THEY WATCH "SESAME STREET"

(By Edward L. Palmer)

Who is the toughest television audience in the country? As far as I'm concerned, there is no question about it: preschoolers. This group of three- to five-year-old children comprises the most demanding and mercurial collection of viewers anywhere. And there are an estimated 12 million of them in the United States.

Starting November 10, these preschoolers will be the object of an unprecedented and potentially significant experiment in educational television. On that morning. National Educational Television will beam to 163 public television stations across the country the first of a series of 130 hour-long color telecasts specifically designed to prepare young children for formal schooling. The primary objective of the experiment is to determine whether the techniques and approaches that are popular and effective in commercial television can be adapted successfully to teaching.

In short, can television really teach preschoolers?

This is still an open question for several reasons. First of all, the Nation's total experience in instructional television has been, at best, inconclusive. When television has been used for instruction, the usual practice has been simply to transmit existing classroom circumstances.

On the other hand, we know that when television is used imaginatively and on its own terms, it has an observable—if, perhaps, unintended—instructional impact. Young children, for example, have learned words, numbers, shapes, and colors from television commercials—messages primarily intended to sell products to older persons.

Then too, there has been no large-scale effort during the 20-year history of television to explore its potential as a medium of instruction. The large sums such an undertaking would involve heretofore have not been available.

Thus, the 26-week experimental series, called "Sesame Street," which is being created and produced by the Children's Television Workshop (CTW), is unique With grants totaling $8 million from The Carnegie Corporation. The Ford Foundation, the U.S. Office of Education, the Office of Economic Opportunity, and other Federal agencies, CTW has the resources to undertake a major program in instructional television. It is being guided by executive director Joan Ganz Cooney, an award-winning producer of documentaries who directed a detailed study of television's potential in preschool education for Carnegie Corporation, and by executive producer David D. Connell, who was associated with CBS's "Captain Kangaroo" program for 12 years.

Actually, the "Sesame Street" series represents not one experiment, but several It is an experiment in public broadcasting, preschool instruction, film and television production, formative research and evaluation, and the use of professional audience building techniques. One unusual facet of the experiment is the close working partnership between research and production.

Virtually all of the research is undertaken in direct response to the practical and urgent needs of production. Underlying these close ties is the nature of the preschool audience. It is relatively difficult to sustain the interest of young children, as parents and others who have worked with them know. Thus, to capture their attention and hold it for a full hour, day after day and week after week, is a formidable assignment.

Preschoolers, we have found, are highly selective. They do not retain an interest in a television show on a program-to-program basis, but rather on a moment-to-moment basis. And yet, if the CTW experiment is to be successful, we must make every effort to sustain their interest virtually from start to finish.

Because of this imperative, "Sesame Street" will be the most researched, tested, and studied program in television history by the time it goes on the air this fall. Very little—if, indeed, anything—is being taken for granted.

We began our studies at GTW by examining existing children's material—films and television programs—to see what captured and sustained the interest of preschoolers. For example, we learned that our best chance to research a young child would be with material clearly built for him. In other words, every element in "Sesame Street" must say to every preschoolers, "This is for you."

1/ U.S. Congress. House. Committee on Education and Labor. General Subcommittee on Education. Needs for Elementary and Secondary Education for the Seventies. Hearings, 91st Congress, 1st session. Washington, U.S. Govt. Print. Off., 1969. P. 140-145. Held Oct. and Nov. 1969. (Hereafter cited as Needs of Elementary and Secondary Education)

In this television age, receivers are turned on from 50 to 60 hours a week in the homes of young children. As a result, preschoolers soon become highly selective. The young child posts an extremely sensitive guard that signals whether adult or child television fare is coming up. This is primarily an auditory monitoring that functions when the child is anywhere within earshot of a television set. Because of the television savvy which the preschooler develops, we must devise ways of motivating young children of all backgrounds—middle class and disadvantaged—to watch "Sesame Street." Our task is particularly challenging because our audience is neither physically present nor captive, but rather "out there." Even if placed before the set by a mother, preschoolers still have clear options to watch the entire program or portions of it, to turn to another channel, or to turn off the set altogether.

The producers must make the show entertaining without compromising the instructional objectives. Unless "Sesame Street" is as entertaining as other programs children watch every day, the CTW experiment will fail at the very outset.

To head off this possibility, show materials and new ideas are constantly subjected to judgments of the "ultimate consumers"—ad hoc panels of preschool children themselves. For example, our cartoon designed to teach the letter J was created along the lines of a television spot commercial. Two small boys are shown talking when the letter J appears from the top of the screen. One of the boys says it looks like a fish hook. But a voice off screen immediately tells them it is the letter J and then asks them if they would like to hear a story about it. An animated, rhythmic nonsense jingle that capitalizes on the appeal of absurdities to children follows:

Once upon a time a guy named Joe
Noticed a June bug on his toe
Put it in a jar and started to go
But here come the Judge and said, "No, no, no."
But Joe said, "Why?" and started to jump
And danced a jig on an old tree stump
And jogged along to the city dump
Where he jammed the June bug in a tire pump.
And the Judge caught up and started to wail,
Said to Joe, "Justice will prevail."
And the jury met and set the bail
And Joe got an hour in the city jail.

This piece of animation, called the J Spot, was the first commissioned by CTW in the fall of 1968. It arrived in January and since then has been subjected to constant study and dissection. The things we learned from our research with this spot have helped guide and improve productions that have been made since.

In testing the J Spot on children with backgrounds that ranged from disadvantaged to middle class, we found that as few as four or five repetitions an hour during regular children's programing established 100 percent recognition of the letter J. We also confirmed what we had already suspected from watching children view commercials; namely, they were not bored by the repetition. On the contrary, some tried to repeat the jingle after hearing it for the second or third time. However, in experimenting with a shorter version of the jingle, we found the children were even more responsive and willing to repeat the words. This suggested the spot had value for children who learn quickly and want to go beyond mere recognition of the letter, which was the basic aim of the cartoon.

Further research also suggested that if young children actually participate in a jingle such as the J Spot, or are otherwise involved with some element of a program, they tend to learn more. Oddly enough, we found that three-year-olds were more inclined to sing and talk along with the spot than four-year-olds. Our theory is that the younger children are less inhibited than the slightly older ones, particularly if adults are in the same room during the test. In any case, we are trying whenever possible to build in opportunities for child participation.

In one of a number of research methods, we visit a day care center in New York City and show a piece of material to preschoolers, often to one child at a time. We run the piece on a television set tied to a portable video-tape play-back unit and then place a "distractor"—a television-size rear screen projector which shows a different slide every eight seconds—nearby. We then measure the proportion of each eight-second interval when a child is watching our television presentation as opposed to looking at anything else, including the distractor.

The data, accumulated on graphs, is carefully analyzed in company with the program's producers to determine why attention rose or fell during the test piece.

Our preliminary findings confirmed what Walt Disney knew all along: Cartoons are a sure fire way to capture and sustain the attention of children However, young children seem to prefer an even simpler visual display than is seen in a typical theatrical cartoon

We also gave some of the preschoolers in our test preliminary briefings to determine whether the advance information would heighten their attention to certain elements. The particular cartoon we used for one such test disclosed no appreciable difference. For example, we urged one group of four-year-olds to take special notice of what each character in the cartoon ate. We asked another group to note the feats the animals could do that a little boy in the cartoon could not—such as swing from limb to limb. Those prompted to watch for one kind of event didn't answer our questions much better than those who had not been alerted. This led our producers to surmise that we really can't set up our audience to see one thing or another in an upcoming sequence. Each segment must speak for itself and make its points unmistakably clear.

Though we expected to find a high interest in cartoons, we did not anticipate the fascination many preschoolers revealed for a technique known as "pixilation." This involves the deletion of frames in a motion picture film strip and results in the image moving in a speeded-up fashion that can be rather amusing.

Our research also disclosed that young children are unlikely to remain interested for long if an adult talks full-face to them. The language problems simply are too severe for preschoolers. They have enormous difficulty in constructing a mental image of a scene from a spoken description. However, we found that interest can be maintained for a longer period if, as the adult speaks, the camera shows what the person is referring to, such as a pair of shoes, an animal, or a home

Talk not directed specifically to the children's level almost instantly causes attention to begin wandering even if the words come from puppets we know the children otherwise enjoy watching. Also, if there's extensive talk between puppets, or between others on the screen, but not to the audience, chances are that young viewers will not remain interested very long. Attention span, we now strongly suspect, seems more a function of the visual display than of a child's particular makeup and background

As a result of our research with young children, we developed several working guidelines for what is most likely to arouse and retain their interest. Here are some of them:

Television material should be lively, full of novelty, have considerable variety, and, as much as possible, use animals, young children, and adults who speak in a friendly and affirming manner.

These guidelines, however, are just that: They are neither the last word nor foolproof. We prepared a live-action sequence to explore the concept of rectangles. Theoretically it had all of the elements to assure success: novelty, variety, fast pace, and general visual sophistication. But it didn't work It had too much of all of these qualities. As a result, the attention of our preschool audience wandered; there was no evidence they had learned the concept, and, indeed, some seemed confused.

The guidelines made repetition and the spacing of key television pieces for "Sesame Street" important considerations. Take repetition for example: We must build into each segment of the program several simultaneous levels of learning readiness so that three-year-olds as well as five-year-olds learn something from each viewing. Accordingly, repetition is essential to insure the maximum planned effect.

The pieces we expect to repeat will all have bouncy melodies or humorous endings, and some may hape a slightly different twist each time. In our "Countdown" series of spots, for example, each sequence begins with a 10-second rocket-launch countdown designed to teach numbers and ends with a mock disaster. In one sequence, the rocket falls over at blast-off. In another, the rocket lifts off, but covers the launch director and nearby spectators with a cloud of black smoke. In a third, the launch director and not the rocket zooms into space.

Spacing is important, too. But how much? How many times should a one-minute spot be repeated to attain the intended level of learning? Five times in a one-hour show? Once each day for five days? For the J Spot, our research indicated that five times a day is more effective than one showing a day for five days. The spacing, of course, may differ from piece to piece.

Another of our major research functions is to build test items that are consistent with our curriculum objectives. These objectives were worked out by leading educators, child development experts, schoolteachers, film makers, and television professionals during a series of five three-day seminars in the summer of 1968. Their recommendations, in essence, suggested preschoolers should know letters, numbers, geometric forms, and how to reason and solve problems. They also should be familiar with their physical and social environments.

CTW producers are now designing experimental films to meet objectives in each of these curriculum goal areas. Before the films could be shot, however, research had to determine what the potential audience already knew about a given subject. We designed special tests for this purpose and administered them to large numbers of three-, four-, and five-year-old children. The results of these tests tell producers the level of letter and number recognition for which their spots should be designed.

We also constructed test items to determine how effective each piece of completed production material is when it is actually shown to preshool children. We built a J Spot test item, for example to, see whether the J sound in words starting with that letter was picked up by the children. We showed line drawings of a jacket, dog, airplane, and table to preschoolers who had seen the J Spot. Then we'd ask them to select the picture with the object that begins with the letter J. This was a difficult test and not many succeeded in connecting a drawing of a jacket with the initial letter and sound of J.

In our field work thus far, we have turned up some interesting, if perhaps inconclusive, general findings. We found the voice and mannerism of a performer are important to a young child. Many children, we learned, were distracted and puzzled when an attractive film star with a naturally husky voice read a story. When she first appeared on the television set, the children appeared delighted and expectant. But as she began reading, they asked what was wrong—"Was she sick?" Her voice simply did not match her face.

In another instance, a group of preschoolers watched a film featuring Bill Cosby of "I Spy" fame and persisted in identifying him with that program Instead of accepting his solo performance, they kept waiting for his "I Spy" partner, Kelly, to appear.

One segment in "Sesame Street" takes advantage of the current genre of adventure satires such as "Batman," "Man from UNCLE," and "Get Smart." The sequence, which may become a regular feature of the series, is a spoof called "The Man from Alphabet." The man himself is a bumbling anti-hero in a trench-coat, whose antagonists are the arch illiterates Digby Dropout and his assistant, Dunce.

In a typical episode, the man from Alphabet gets orders from his boss, "Teacher," and heads directly for a newsstand operated by a seven-year-old boy, "H.B.," who is the brains behind the Alphabet operation. H.B. patiently leads the man from Alphabet through a logical reasoning sequence that concludes with the solution to that day's mystery.

The series will be on several levels to permit younger children to watch it on their levels of perception while their older brothers and sisters—and parents—can react on their own planes.

Three or four hosts, black and white, will provide the show with continuity and also reinforce the educational elements of the program. More important, the hosts will give the show the human warmth so essential to young viewers They probably will be supplemented by guest celebrities who would appear in cameo roles. Some of these star appearances will be for the purpose of capturing and holding the mothers' as well as the children's attention. Mothers most likely will have to turn on the television sets and, hence, are important factors in the design of the production.

The show's home base, "Sesame Street"—named after the "Open Sesame!" command from the tale of Ali Baba and the Forty Thieves—is the front stoop of a small apartment house, where the host will talk with passers-by and to the audience. A candy store and an excavation surrounded by a fence of colorful "doors" are nearby. Through these doors viewers will explore the worlds of fact and fantasy, of farms, animals, and outer space.

In addition to the prebroadcast research at CTW, an entirely separate phase of research and evaluation will be undertaken by an independent agency, Educational Testing Service (ETS) of Princeton, N.J. The ETS is testing a nationwide sample of pre-schoolers before the series begins and will test the same group after it has concluded to determine how much the children learned from the show.

The entire Children's Television Workshop experiment rests on several educationally and socially significant premises. Clearly, a substantial and significant portion of a person's intellectual development occurs before he enters kindergarten. We also know that the disadvantaged child often reaches the first grade as much as a year or two behind his middle class classmates in some areas of intellectual development. Frequently, he falls further behind as his schooling progresses.

A start in school for all children at age four, though endorsed by educators and government leaders, would cost an estimated $2.75 billion, not including the cost of classrooms to house the more than five million additional children. On the other hand, television is everywhere. In fact, 90 percent of households with incomes of less than $5,000 a year own at least one television set. The challenge is to get the people in those homes to turn on "Sesame Street." Many of the stations carrying the program are on ultra high frequency (UHF) and few of the target families, particularly in the critical inner-city areas, are in the habit of tuning to the UHF channels. CTW is trying to prepare the way with an extensive information and promotion effort directed specifically to mothers and also to teachers at child day care centers. They are the keys to the campaign, because it is they who must be reminded to turn on the television set at the right time. Also, UHF channels are sometimes difficult to focus, so mothers must know exactly how to do it.

An important part of the promotion effort will be to encourage city mothers to form volunteer viewing groups in which each mother takes her turn as hostess-teacher and invites the children of neighbors to view the show in her home. CTW will prepare and distribute colorful program guides that will inform mothers of the educational contents of upcoming shows and suggest follow-up activities to reinforce the program's daily fare.

In all its facets, "Sesame Street' is a pioneering experiment in the constructive use of television. We believe it will be worth the money and effort if it only answers the basic question: Can television really teach? It will truly be a success if the young viewers learn as much from "Sesame Street" as CTW and instructional television generally are learning in the process of its preparation.

For further information, write to Children's Television Workshop, 1865 Broadway, New York, N.Y. 10023.

APPENDIX 4

Commission on Instructional Technology: Six Recommendations 1/

RECOMMENDATION No. 1

WE RECOMMEND:

A new institution—the National Institutes of Education (NIE)—should be established by Congress within the Department of Health, Education, and Welfare, reporting directly to the Assistant Secretary for Education.

The National Institutes of Education should be broadly authorized to develop, support, and fund greatly strengthened programs in educational research, development, and application (R.D. & A.).

The National Institutes of Education should comprise several constituent institutes, through which grants would be made to universities and other independent research institutions. The institutes would also conduct research themselves. The NIE should sponsor, among other things, several strong autonomous regional R.D. & A. centers, plus a small number of comprehensive demonstration projects.

The proposed National Institutes of Education—well-funded, broadly based, and building on present strengths and successful programs (public and private)—would give concentrated leadership and direction to a national effort to improve learning and teaching at every level of education. The organization should start with a few component institutes focused on critical areas. This report proposes the creation of a National Institute of Instructional Technology (see Recommendation No. 2), including a center or "library" of educational resources (see Recommendation No. 3). In addition, the National Institutes of Education might create other institutes, as for instance one concentrating on learning research, one on teaching and curriculum development, and another on educational organization, finance, and management. A prime function of the NIE as the parent body would be to ensure close cooperation and feedback among the institutes. Their provinces would obviously overlap and it is important to avoid perpetuating conventional and unproductive divisions.

Instructional technology simultaneously draws from and contributes to an underlying science of learning. The technology of instruction is shaped by, as it will shape, the purposes and the substance of education. Unless technological means are harnessed to humane ends, with full regard for individual diversity and needs, no real benefit will accrue to society—indeed, the reverse is more likely.

Furthermore, instructional technology is integrally involved with the process of learning and the genuine individualization of learning. Any sharp distinction, then, between research and development in instructional technology, on the one hand, and research and development in the basics of education, on the other, appears to us to be arbitrary. In fact, this very division has contributed to the disappointing

---

1/ U.S. Congress. House. Committee on Education and Labor. Select Subcommittee on Education. Educational Technology Act of 1969. Hearing, 91st Congress, 2nd Session. Held Mar. 12, 1970. Washington, U.S. Govt. Print. Off., 1971. p. 39-62. (Hereafter cited as Educational Technology Act of 1969).

impact thus far of instructional technology—so frequently heralded, so seldom realized down the years since 1913 when Edison proclaimed the motion picture as the prospective agent of complete school reform.

The National Institutes of Education and its component institutes would undertake a limited amount of research, development, and application themselves. This proportion should be relatively small, however—perhaps 10 to 15 percent. The majority of the work should be executed through grants made by the institutes to selected institutions, both public and private.

The Commission recognizes the importance of conducting both basic and direct research. Basic research, in which the investigator is free to formulate his own questions, can lead to far-reaching discoveries which could not be defined in a blueprint for investigation. On the other hand, directed research, in which the questions are clearly structured, can be a powerful tool for achieving specific desired results.

Each institute should establish subsidiary research, development, and application programs, tied in closely with individual institutions and with existing and projected regional centers. The National Institutes of Education and its component institutes should work closely with state educational agencies, especially state departments of education, and with the Education Commission of the States.

To insure maximum effectiveness and influence, the National Institutes of Education should be a strong arm of the Department of Health, Education, and Welfare, reporting directly to the Assistant Secretary for Education [1] as shown in the chart on page 41.

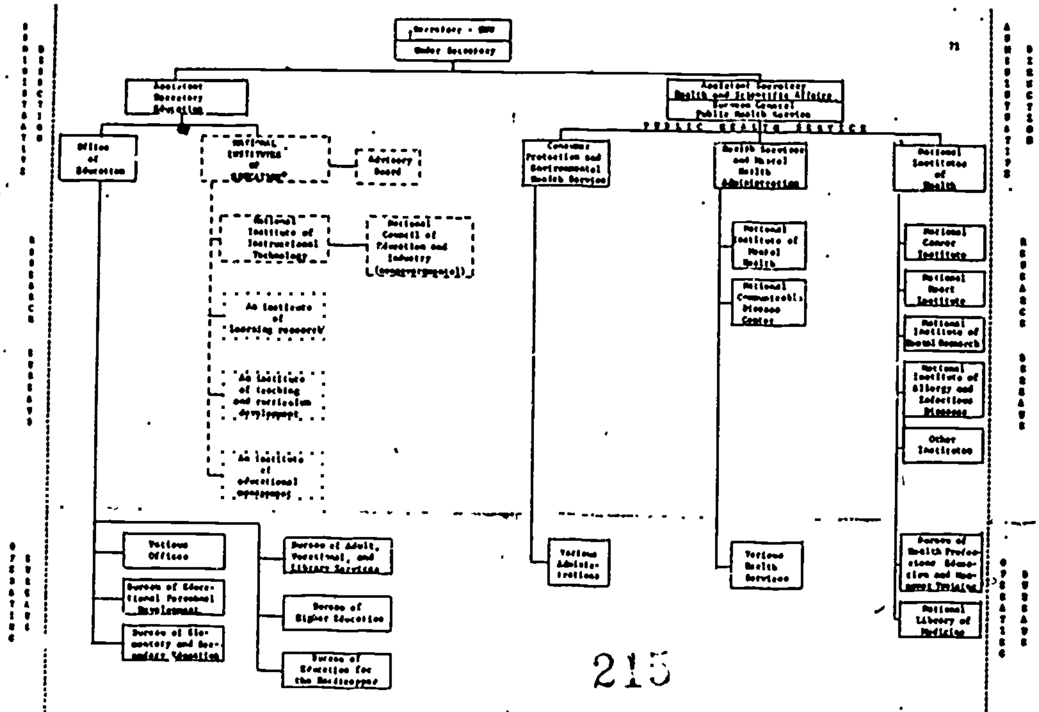
The National Institutes of Education should be headed by a director with outstanding qualifications appointed by the President and aided in policy making by a small strong top-level Advisory Board, composed of government and nongovernment representatives. Each constituent institute should also be headed by a highly qualified director. Together the Advisory Board and the directors would act as a council to coordinate the work of the NIE.

Through its national visibility and stature, the National Institutes of Education should build up educational research, development, and application throughout the nation. Everywhere—in universities and school systems and state departments of education—there are able, dedicated people working on new approaches to solving educational problems. The National Institutes of Education should strengthen promising work now going on, encourage initiative and invention, and support a diversity of approaches to critical problems. In Recommendation No. 2 we indicate how one of the institutes—the National Institute of Instructional Technology—could accomplish some of these objectives.

Tradition of Federal Research, Development, and Application Leadership

The establishment of a federal institution such as the National Institutes of Education would be entirely in the mainstream of Ameri-

[1] NOTE.—The Commission believes that the Federal Government's top official for education should be upgraded to the level of Under Secretary at least and ultimately to a full Secretary, either under the Secretary of Health, Education, and Welfare or as head of a separate new cabinet level Department of Education.



* Will incorporate the functions of the Bureau of Research.

can tradition. There are outstanding precedents for federal action of this magnitude in other fields. For instance:

Agriculture.—Since 1862, when President Lincoln signed the Congressional acts creating the U.S. Department of Agriculture and the land-grant colleges, the department has initiated, funded, and supervised a vast program of research, development, and demonstration projects. Today, the department works closely with state agricultural experiment stations, the Cooperative Extension Service, industry, and other agencies in a complex of projects related to rural affairs. Coordination of all the department's research and educational activities is the responsibility of the Science and Education Director, who reports directly to the Under Secretary. They include direct research (for example, at Beltsville, Maryland), research done in cooperation with the state experimental stations and other agencies, the Federal Extension Service which applies research findings to day-to-day rural problems, and the largest library on agriculture in the country.

The federal-state-local agricultural research program comprises comprehensive research and development in agriculture and forestry—ranging from basic research to direct application of R&D results to individual farms, families, and business firms involved with agriculture. The program is financed on a matching-fund basis, with the states matching the federal funds allotted and with counties also contributing to extension services. Currently government funds for agricultural R&D amount to about $450 million annually; industry provides an equal amount in addition. As a direct result of agricultural R&D, the productivity of American farmers has multiplied many times.

Health.—A large part of the nation's biomedical research and training is concentrated in the National Institutes of Health. Federal funds for these activities grew significantly during the 1950s, as Congress recognized important new prospects for improving the nation's health through research (triggered in part by the discovery of the Salk vaccine and spectacular developments in the new sulfa, antibiotic, and other drugs). By 1970 the total budget of the National Institutes of Health (including ten separate research institutes and certain other responsibilities, notably health manpower) is expected to be $1.5 billion.

The National Institutes of Health is primarily concerned with research—not development—and with education in the health field. Nearly 90 percent of NIH-sponsored activities is "extramural," i.e., it is carried out through grants to universities, medical schools, hospitals, clinics, etc. The remaining 10 percent includes NIH's own extensive research activities at Bethesda, Maryland. Although the National Institutes of Health is part of the Public Health Service on the official organization chart, the head of NIH reports directly to the Secretary of Health, Education, and Welfare, through the Assistant Secretary for Health and Scientific Affairs.

NIH-sponsored research has made possible a better understanding of the underlying causes of cancer, heart disease, and other illnesses—an understanding which brings closer the day when these diseases will be successfully cured and, ultimately, prevented. Development of a rubella vaccine, improved treatment of acute leukemia in children, and a successful cure of a rare cancer affecting young women (choriocarcinoma) are but a few of the fruits of NIH research. Other developments, such as progress in the deciphering of the genetic code, have far-reaching implications for the entire field of medical and biological sciences.

Need for New Effort in American Education

Education has long needed a national research effort, commensurate with those in agriculture and health, focused on the improvement of learning and teaching. Now is the prime moment to bring all available resources to bear in strengthening educational research, development, and innovation, which for far too long have commanded insufficient funds and talent.

While many basic questions still remain unanswered or disputed, there are encouraging additions being made to man's understanding of the hows and whys of human learning in all its variations. One important reason is the gradual coming together of research specialists who once operated almost in isolation: new findings from the laboratory studies of human and animal learning, for example, are interacting with findings from actual classrooms.

Today America needs to examine the basic assumptions (too often unexamined) on which schools and colleges operate. If indeed schools are to be humane environments for learning and not mere institutional accumulations, if diplomas and degrees are to be more than mere passes to economic and social acceptance, America's vast decentralized educational "system" must undergo a revision that draws upon the best insights that can be cultivated: from scholars of diverse disciplines, teachers, philosophers, and artists, administrators, citizens generally, and from the ultimate consumer—the student.

In recent years, the federal government has spent increasing amounts for education. Under the Elementary and Secondary Education Act of 1965, for example, about $4 billion has been allocated to upgrade education in deprived areas. But these funds were not invested to get to the roots of education's problems, nor to design a system with more adequate theoretical and technological foundations. The money has been used primarily to repair and extend the present system.

The Commission has concluded that the nation's investment in education must be increased and its thrust changed if America is to resolve its present basic educational and social problems. To be sure, public expenditures on education are nominally accepted as an "investment" in the nation's economic and social future. But the situation today requires that substantial funds for education be allotted for investment more strictly construed: as capital to create an improved system of teaching and learning which will produce more real individual and social achievement for each dollar spent than is done by the present system.

The Commission believes that the problems of teaching and learning could yield to an organized and systematic attack, and that the refinement and imaginative use of instructional technology could contribute signally to the success of that attack. Certainly the solution of education's problems is as critical for the nation's future well-being as is a cure for cancer, heart disease, or stroke, or the development of more efficient techniques for growing and harvesting wheat.

A New Emphasis: Development and Application

Fully as urgent as expanded, sharply focused research is the need to improve the essential follow-through known as development and application. The process of successful innovation entails several stages. First, there is specific development which produces from a new idea a particular program—for teaching reading to children in the early grades, for instance. Second, there is a design-and-proving stage, to test the new program in the schools. Third, training and follow-through enable key people to run broader trials in the schools, and constantly feed back information on problems and discoveries which may modify the program. Finally, there is a transmission of the new program in usable form to interested schools throughout the nation.

There is, of course, seldom so orderly a process as this sequence suggests. The role of creation, of pure *invention*, is all-important in education as in any other science or art. And it would be stultifying if innovation had to wait on solid research results and development procedures. The ideal process that needs support and encouragement is circular: the bright idea, successfully improvised by a teacher, administrator, or student can spur research, as well as the other way around.

It is clear, moreover, that even the best programs of research, development, invention, and application, if they are to have practical, large-scale effects, require improved efforts in packaging, disseminating, and evaluating. Therefore, educational improvement could be furthered by concentrating funds and effort on disseminating *outstanding* theoretical and empirical findings in usable form. Increased funds could be applied, for example, to quicker and wider communication of important findings through television, radio, and other news media.

Further details with respect to the National Institutes of Education

1. The National Institutes of Education, through its various constituent institutes, should take over the activities of the Office of Education's present Bureau of Research, which include the ten Research and Development Centers and the fifteen Regional Educational Laboratories funded under title IV of the Elementary and Secondary Education Act of 1965. It should also assume such other educational research, development, and application projects as clearly fall within its purview.[3]

The recommendation that a new agency absorb the present functions of the Bureau of Research implies no derogation of that hard-pressed organization which in its brief existence has made a marked contribution, quantitatively and qualitatively, to education. Federal support for educational research, however, is still wholly inadequate. The total for 1969 (all of it in the form of grants or contracts) amounts to no more than $125 million, and goes largely for applied research, very little for basic research or for development. Moreover, in the summer of 1969, the research program is in the midst of a cutback.

2. The National Institutes of Education should also be expected to maintain close ties with relevant research and development being conducted in the many federal agencies outside the Department of Health,

[3] The National Institutes of Education should assume only the *research* responsibilities now under the Office of Education. Operating programs (see chart, p. 41), which now make up the bulk of OE programs, should remain in the Office of Education.

Education, and Welfare that operate education programs;[3] also with the American Educational Research Association and with practitioners in other relevant diciplines such as social scientists and engineers.

3. The National Institutes of Educa... ...ould use the research models in agriculture and health as guides. In its disposition of research funds, for instance, the NIE might well follow the lead of the National Institutes of Health in concentrating research in universities and other research-oriented institutions through grants. In other important matters, however, agricultural research and development might offer a more appropriate model; e.g., with respect to the close collaboration maintained with state and local agencies and the emphasis on development and application as well as basic research.

4. The National Institutes of Education proposed in this report may well be involved in research projects running three to five years or more in length. Annual funding in the ordinary way would limit the effectiveness of such projects. The new organization, therefore, should explore with the Bureau of the Budget the possibility of obtaining authority to use "no-year appropriations" for research programs, or forward-funding arrangements (100 percent committed for the first year, two-thirds for the second year, and one-third for the third year) similar to those developed by a number of government agencies including the National Science Foundation, the Atomic Energy Commission, the Environmental Science Services Administration, the National Aeronautics and Space Administration, and the Department of Defense.

RECOMMENDATION No. 2

WE RECOMMEND:

A National Institute of Instructional Technology (NIIT) should be established as a constituent of the proposed National Institutes of Education. The purpose of the NIIT should be to improve American education at all levels through the use of instructional technology. The focus of the Institute's activities should be on research, development, and application in equipment, instructional materials, and systems, and also in training personnel.

The proposed National Institute of Instructional Technology should strengthen and promote the most promising of the Research and Development Centers and Regional Educational Laboratories (now operating under title IV of the Elementary and Secondary Education Act of 1965) which are conducting programs involving instructional technology, and should establish such other regional centers as it deems necessary.

The National Institute of Instructional Technology should increase significantly the quality and quantity of the research, development, dissemination, and action programs needed to fulfill instructional technology's potential for advancing learning and teaching.

[3] Among these other agencies are the Atomic Energy Commission, the National Aeronautics and Space Administration, the National Science Foundation, the Office of Economic Opportunity, the Department of Labor, and the armed forces. (The U.S. Office of Education budget in fact, has never amounted to more than one-half of the total Federal funds devoted to "education and manpower".) Another relevant private public enterprise of importance is the program recently established by the Office of Education with the National Academy of Sciences and the National Acedmy of Education to finance basic research in education.

Like its fellow institutes, the National Institute of Instructional Technology could be a new locus of talent, energy, expertise, and imagination for American education, providing leadership and initiative for efforts from many sources. It should bring together scholars from many disciplines and experts from the various media representing divergent viewpoints, including talented people who have hitherto dedicated themselves primarily to their own professional fields and organizations and to their own communities and institutions.

The influence and impact of the National Institute of Instructional Technology, like the National Institutes of Education as a whole, would derive principally from the stature and performance of the people mobilized, and from the initiative taken in advancing educational improvement. By its use of funds, its development and dissemination of new ideas, and its direction of selected pilot programs to achieve innovation in schools and colleges, the National Institute of Instructional Technology should generate a new, more coherent thrust toward continuing improvement throughout American education. Its work and that of the other institutes should serve as guides for the many programs carried out through the Office of Education—a cooperative way of translating researched, developed, and tested methods and ideas into effective action programs.

In line with the general policies for the proposed National Institutes of Education outlined in Recommendation No. 1, the National Institute of Instructional Technology should instigate and sustain programs of research, development, and application relating to its responsibility. It should encourage and support regional, state, and local activities, encourage initiative and invention, and provide a diversity of approaches to the critical problems of instruction in the schools and colleges. Of first importance would be the National Institute of Instructional Technology's leadership in finding effective ways to improve and expand the production of educational materials—perhaps through the creation of new production centers that would draw on both public and private resources.[4]

The Commission cannot emphasize too strongly the importance of "a diversity of approaches." The National Institutes of Education and its constituent institutes should constantly foster *alternative* schemes, in much the same way as systems analysis encourages alternative solutions to an objective that has been established. The problems of education will not be solved by any one approach. The very diversity of human beings and cultural patterns demand diverse approaches. In the past, education has tended to overlook this diversity and has been inclined to proceed on the assumption that everyone should be able to learn in much the same way. We propose, therefore, a decentralized pattern for the programs sponsored and coordinated by the National Institute of Instructional Technology, and we envisage regional clusters of institutions—universities, school systems, state departments of education, production centers—working together on projects of common interest and of national significance.

The Commission strongly endorses the concept and objectives of the Research and Development Centers and Regional Educational Labo-

[4] An example of combined efforts is the Children's Television Workshop, which is scheduled to go on the air in the fall of 1969.

ratories.[5] In line with the institutional pattern outlined above, certain centers and laboratories would clearly fall within the scope of the National Institute of Instructional Technology. All the laboratories make some application of technology, with considerable variation in the degree of sophistication of the various programs. A few of the Research and Development Centers, such as Pittsburgh, Johns Hopkins, and Stanford, stress technology. The center at the University of Pittsburgh has been outstanding in combining basic research with regular programs in the local schools. This center and others are in effect providing models and prototypes for further development by the Regional Educational Laboratories.

But underfinancing has been a major handicap in the evolution of these fledgling enterprises, both centers and laboratories, and has slowed down their contribution to education. In comparison with the amount of federal support for the major research and development installations in other fields, the federal support for educational research, development, and application must be described as token. The Jet Propulsion Laboratory, sponsored by the National Aeronautics and Space Administration, and the Lawrence Radiation Laboratory, sponsored by the Atomic Energy Commission, each receive 20 percent or more of the total federal obligation for university-administered research and development; no Research and Development Center in education has ever received much more than 1 percent of the total.

The Commission proposes that those laboratories and centers making the most promising advances in the use of instructional technology be funded by the proposed National Institute of Instructional Technology, that the institute be empowered to establish new centers as needed, and that these laboratories and centers be adequately financed, well-directed, competently staffed, and then encouraged to operate with genuine independence. The new centers should, for the most part, conduct multipurpose research, development, and application.[6] Exceptions would be R.D. & A. in high-cost experimentation which would necessarily be more highly specialized.

The National Institute of Instructional Technology should provide a meeting ground for the many organizations concerned with media, such as the Corporation for Public Broadcasting, state agencies including public broadcasting authorities, and the diverse groups with some interest in the technology field.[7] Although increasing numbers of classrooms make some use of instructional films, television programs,

---

[5] The Research and Development Centers and Regional Educational Laboratories operate under grants from the U.S. Office of Education's Bureau of Research. The R & D Centers all located within universities, were originally organized to provide basic research, development, and dissemination. Each center aims to bring interdisciplinary talent and resources to focus on a broad problem of particular significance to education and then to design programs to meet it. The Regional Educational Laboratories, on the other hand were established as an effort to bridge the gap between educational research and practice—in effect, the "application" part of R.D. & A. They were expected to work much more closely with local schools than the Research and Development Centers—to select promising research and development activities, demonstrate their effectiveness, adapt materials and techniques for practical use in the schools, and disseminate their findings.

[6] The centers could also provide facilities (and possibly funds) for teachers and others with talent and ideas to experiment with the production of instructional materials employing a variety of media.

[7] For example, the National Education Association, the American Federation of Teachers, NEA's Department of Audiovisual Instruction, the Joint Council on Educational Telecommunications, the National Association of Educational Broadcasters, the American Association of School Librarians, the Association of College and Research Libraries, the National Audio-Visual Association, the Educational Media Council, the American Council on Education, and the American Library Association.

tapes, records etc., the exponents and practitioners of the various instructional media operate without sufficient contact, coordination, and cross-fertilization. "Media apartheid," as one expert calls it, has helped to subordinate nonprint media to the hegemony of the printed book. Moreover, professional associations and the organization of schools and colleges (for example, the separation of the library, the audio-visual center, the television stations, and the computer facility from one another—even though all of them should be collaborating on instructional programing) have encouraged this separation. Instructional technology needs a central agency with national stature which could function as a base for those outstanding practitioners from each field who want to work with others across media boundaries to apply their knowledge, experience, and insight to the solution of pressing educational problems.

An essential counterpart to the efforts to use technology for more effective instruction is research, development, and application in the techniques for storing and retrieving information in all media. There is need to develop better tools for the analysis of library and information requirements and improved ways of measuring the value of existing systems and services. The Commission, in considering this problem, finds itself in agreement with recent recommendations of the National Advisory Commission on Libraries.[*] A principal recommendation was for a Federal Institute of Library and Information Science to conduct basic and applied research aimed at using technology to improve library services. The National Institute of Instructional Technology would be a logical location for these functions.

Another highly important feature of the research, development, and application efforts recommended here should be worldwide cooperation in the full utilization of instructional technology. If technology's potential can be thoroughly explored, analyzed, and confirmed in the United States, the results could be adapted to the educational needs of other countries—with particular impact on the developing nations. Also of importance are the lessons the United States could learn from other countries, a number of which are experimenting widely with instructional technology.[*] International collaboration could reduce duplication of research, development, and application and speed the advancement of education in the United States and throughout the world.

Major functions and programs envisaged for the National Institute of Instructional Technology are spelled out in further detail in Recommendations Nos. 3 through 6, which, together with the details in this recommendation, reflect the following priorities:

- Fundamental research in technology as a total system, both in helping to find answers about the learning and teaching processes and in putting research results into practical application.
- Development of a system by which practicing educators in schools and colleges throughout the country would have ready access to the widest possible range of materials and resources for instruction, in every medium and subject.

[*] In a report to the President of the United States, entitled *Library Services for the Nation's Needs*, July 1968.

[*] To cite one example, Japan has been a world leader in the use of instructional television, and should have much to offer in the way of advice, direction, and example.

- Improvement of methods of evaluating the relative effectiveness of various educational resources (human and nonhuman) and their combinations in the learning patterns of individual students.
- Exploration of means for developing high-quality educational materials comparable in sophistication to the machines or equipment now available or about to be available.
- Development and application of improved methods of preparing teachers, administrators, and many different kinds of specialists in the best uses of instructional technology, including access to reliable comparative economic and performance data on hardware, programs, and technological systems.
- Collaboration with industry in exploring ways to develop hardware especially suited to instructional needs.
- Concentration of all the foregoing efforts on helping achieve, through technology, solutions to the nation's most acute educational problems, such as:

  Improving learning in disadvantaged schools, urban and rural; for preschoolers: and for the handicapped.

  Developing the most fruitful approaches to making instruction truly individual.

  Revitalizing liberal arts and professional education and relating higher education more significantly to personal and social experience.

  Developing practical ways for community colleges to meet the diverse and increasing demands being made upon them.

RECOMMENDATION No. 3

WE RECOMMEND:

The proposed National Institute of Instructional Technology should take the lead in efforts to identify, organize, and prepare for distribution the high-quality instructional materials, in all media, capable of improving education.

For this purpose, the National Institute of Instructional Technology should consider establishing a center or "library" of educational resources. Among this agency's responsibilities would be: identifying those areas in which there is a shortage of educational software, and making public these findings; assisting school and college libraries to transform themselves into comprehensive learning centers; and stimulating interconnections (among specialized libraries, data banks, schools, and colleges) for comprehensive and efficient access to instructional materials and educational management data.

The improvement of teaching and learning through the use of instructional technology has been impeded less through the lack of equipment than through the lack of high-quality instructional materials designed for use with the equipment. The Commission has learned from people in virtually every field—teachers and educators, as well as experienced producers in film, television, and the computer—that the insufficiency of excellent materials or programs has been a critical and persistent factor in preventing the development of a genuinely effective instructional technology.

Yet there is a considerable amount of potentially useful material in many media which could be made available to education. The chief problem is that there is no effective system by which materials can be identified, organized, and made conveniently available to educators.[14] Such a system would provide a new wealth of information for the improvement of learning and teaching.

The suggested center or library of educational resources would not be a "library" in the usual sense of a repository of books, magazines, and other printed materials. The most advanced libraries today have begun to expand the usual meaning of "library" by gradually developing into complex information storage and retrieval institutions designed to be much more than a collection of books. The center which the National Institute of Instructional Technology might establish would perform a set of functions quite distinct from collecting books and other instructional materials. It would not itself store the vast amount of relevant resources. Rather, the center would supervise and coordinate a wide range of functions that would include finding, sifting, adapting if necessary, and cataloging materials suitable for educational use. It would provide educators with information about materials in each subject field, for each level of instruction, and in every instructional mode and media. A kindergarten teacher seeking manipulative materials to develop eye-hand coordination, a third-grade teaching team seeking films and audiotapes about the American Indian, a middle-school curriculum supervisor preparing a unit of programmed instruction in mathematics, a high school principal looking into televised courses in Far Eastern culture and history, a college professor desiring to use language-laboratory tapes for teaching introductory Swahili, a graduate university seminar studying the sociology of Latin America, a corporation developing a literacy program for hard-core unemployed—all would be guided by the center to materials relating to their instructional tasks.

Because it would cover all media, all subjects, all levels of education, the center's program would provide a needed synthesis and augmentation of the various national organizations already involved in this field, such as the National Audiovisual Center, the National Instructional Television Center, the Great Plains National Instructional Library, the National Center for Audio Tapes, the National Educational Television Libraries, and the National Medical Audiovisual Center, as well as pertinent collections at the Library of Congress.

This agency should also assist school and college libraries to identify, receive, store, and make available new instructional materials. This would entail their transforming themselves into comprehensive learning centers. Fortunately, many libraries are already far advanced in this reorientation. Further progress should facilitate the development of more flexible, individualized instruction at every level of education.

A central educational resource center would provide educators everywhere with the fruits of "search/find" operations, and might encourage the establishment of working arrangements for exchange of material within educational institutions, libraries, and clearinghouses. These arrangements should be coordinated on a regional basis, with the aim of eventually becoming computer-based.

[14] This gap is in large part the result of the rudimentary state of research and development in the techniques for handling information transmittal in all media. As noted in Recommendation No. 2, the National Institute of Instructional Technology should give high priority to a program designed to meet this need.

Exchange of materials between libraries is an old practice. The computer has made it possible to completely revolutionize this process and has made the planning of networks central to the creation of any new national library facilities. In the last decade a number of computer-based storage and retrieval systems, centers for gathering and dispersing technical information in various fields, and cooperative interconnections of learning institutes have taken shape. But there has been no comprehensive attempt to unite these systems, libraries, and data banks to meet the demand for both instructional materials and research information on the process and management of education.[11] The National Institute of Instructional Technology should take the initiative in exploring possible arrangements for organizing such networks for instructional use.

In the immediate to short-term future, a network could feasibly develop the capability to provide bibliolographic information on educational materials and research, indexed conveniently for the inquirer. However, the long-range future presents the possibility, indeed probability, of full-text access to books via computer, as well as instant transmittal of nonprint media. The realization of this potential, however, requires the solution of several very complex problems, among them the development of principles and practices relating to standardization, compatibility, and copyright.

Systematic coverage and analysis of what exists in all instructional media, subjects, and grade levels would yield an invaluable by-product—the identification of gaps in the supply of instructional materials. The National Institute of Instructional Technology could then keep the whole private sector (including producers and distributors of hardware and software for every level and area of education) informed and aware of the schools' needs and priorities. (This would be done in collaboration with the council suggested in Recommendation No. 6).

Recommendation No. 4

WE RECOMMEND:

The National Institute of Instructional Technology should support demonstration projects designed to improve instruction through the wise exploitation of technology. These projects should be concentrated initially on a few carefully selected communities or individual schools—including urban ghettos, impoverished rural areas, and communities with populations that are predominantly black, Mexican-American, Puerto Rican, or Indian.

The school system of the District of Columbia might be invited to mount the first of such model demonstrations.

The National Institute of Instructional Technology should invite selected schools and communities to participate in demonstration projects and should be responsible for coordinating the use of public and private funds for this purpose. However substantial the amount of

[11] Educators are faced with the problems of accessibility with regard to information about the process and management of education. These data must be readily available if they are to attempt to effectively design conditions of learning along "systems" lines. The ERIC system is attempting to collect and make available such information. It is limited by lack of funds as well as by the difficult problem of reproduction of copyrighted materials. The Commission believes that the ERIC system should be strengthened, and that it should be tied into any network plans established by the National Institute of Instructional Technology.

money involved, the total number of projects should be relatively small, in order to sustain a high-quality, concentrated effort in each one with a saturation of available resources.

Projects should be designed to achieve maximum visibility and impact, and should initially be keyed to meet severe educational problems. The Commission believes, therefore, that the first and largest demonstration might well be in Washington, D.C. The rationale is clear. While education in the nation's capital should be a model of excellence, this city's schools suffer perhaps more than most city school systems from lack of funds, inadequate staff and facilities, preponderance of impoverished minority-group students, flight of the middle classes to the suburbs.

While these demonstration projects would specifically try out technology in its various ramifications, each project should be based on a total educational concept. The choice of schools and communities should take account of prospects for eventual self-support. Strong commitment of school and community leaders therefore would be a prerequisite. In some cases the actual administrative and instructional patterns would have to be altered to accommodate the demonstration. The experiement should include not only public schools and community colleges, but also programs for persons now outside the formal educational system—such as preschool children and unemployed, under-employed, and retired adults.

These comprehensive demonstration projects should operate under the continuing guidance of the National Institute of Instructional Technology and its regional affiliates. Purchase of hardware, physical changes to buildings, and preparation of new curricular material should all be closely interwoven, and the impact of these developments might well stimulate even more fundamental changes.

As for demonstrations designed to benefit out-of-school groups, we suggest that private foundations, industry, and educational institutions be urged to supplement federal, state, and local government funding, and in addition, to provide professional and technical aid. Funding and active collaboration could come from a variety of sources, depending on the projects. For instance:

(*a*) A community agency could develop an educational package in cooperation with a local vocational school, a local television station, local employers, and a nearby university or community college. Citizens could be trained for specific jobs through special counseling and multimedia presentations, including television and programed texts. The "diploma" would be a job.

(*b*) A day-care center could augment its usual activities by installing individual learning carrels equipped with imaginative programed materials for preschool children. Here the children could pursue beginning reading, number concepts, and entertaining introductions to other new worlds—nature, the arts, or certain sciences. Neighborhood housewives, college students, and retired people could, with minimal training, oversee the enterprise without the need for constant attendance of professional teachers.

(*c*) A variety of distribution media (telephone, television, radio) could reach adult audiences at home. Projects for homemakers and workers could be mounted in subjects as diverse as business arithmetic, health care, and computer programing.

Imaginative programs to acquaint the public with the accomplishments and promise of technology in education could prove of great value.

(*d*) The National Institute of Instructional Technology could help design a Job Corps center that would use instructional technology in depth, taking full advantage of the armed services' experience in job training, and trying out various combinations and sequences to meet each student's individual background, capacities, and interests.

Technology could facilitate distribution, presentation, and feedback. It could also encourage cooperation among several agencies—a critial aspect of any successful project. The National Institute of Instructional Technology's challenge would be to bring schools, universities, industries, social agencies, and individual citizens together in active participation and involvement in the advancement of education.

RECOMMENDATION No. 5

WE RECOMMEND:

The National Institute of Instructional Technology should take the initiative in encouraging the development of programs to improve the capacity of educators to make more effective use of instructional technology and programs to train specialists. To this end, the NIIT should support new programs, based on increased research and development:

(1) *To provide administrators and department heads with the knowledge necessary for managing technology effectively;*

(2) *To educate school and college teachers in the most effective uses of instructional technology and in the differentiated staffing patterns technology properly entails;*

(3) *To increase the number of qualified specialists such as producers, programers, and technicians that schools and colleges need if they are to exploit technology fully.*

Besides initiating new programs, the National Institute of Instructional Technology should also strengthen and expand the best existing programs for training and employing educational manpower in the wise application of instructional technology.

"Teaching is the only major occupation of man," Peter Drucker wrote recently, "for which we have not yet developed tools that make an average person capable of competence and performance. But education will be changed, because it is headed straight into a major economic crisis. It is not that we cannot afford the high costs of education; we cannot afford its low productivity. We must get results from the tremendous investment we are making."

In order to increase their productivity, the nation's schools and colleges require a larger supply of diversified, highly qualified manpower. They need administrative leaders—college and university presidents, deans of instruction, department heads, school superintendents, and principals as well as state and federal officials, school board members, and college trustees—who fully understand the prospects for improving education through technology.

In addition, the teacher or professor, from kindergarten through graduate, professional, and continuing education, should understand how new media can be employed to make instruction more effective and more responsive to the individual student.

Moreover, supporting specialists and technicians of many types are needed if a mature technology of instruction is to flourish. The qualifications required in these three categories—administrators, teachers, specialists—are distinctive.

Administrators

In the decades ahead, administrators will be required to make many complex decisions which they are not now being prepared to make wisely. The problems faced by the educational manager are changing rapidly. Tomorrow's educational manager will have to be able to handle a variety of responsibilities, many of them outside the walls of the school or college or state education department. He will need a background in education certainly; but he will also need training and experience in the behavioral and social sciences, in finance and management, and in the development of human resources. The thrust of this recommendation is not toward reviving a "cult of efficiency" for education. Schools and colleges are already overcommitted to rigid formulas for efficiency which prescribe class size, block scheduling, departmentalization, credits, etc. Technology must free, not fetter.

Of great importance, then, is concentrated research, development, and application on the special knowledge school and college managers can make effective use of: what tools are required, what methods (of economic analysis, staff recruitment and deployment, community and staff relations) are most efficacious, how the essential data can be acquired, how purposes and accomplishments can be best evaluated, how educational institutions can be staffed for maximum exploitation of television, recordings, projectors of various kinds, programed instruction, and other kinds of instructional technology—ultimately, how schools and colleges can redesign themselves to educate America's young people most effectively.

The paucity of data even as to the *functions* of administrative manpower in education was recently emphasized by the Office of Education's first report on the state of the education professions, required under the new Educational Professions Development Act. In the matter of instructional technology, the educational manager should understand how to find out what he needs to know about the potentialities and problems of instructional technology, and how to recruit and use the talents of people who can serve in this field effectively. Obviously the school superintendent or university president himself cannot and need not be a sophisticated judge, purchaser, or user of hardware and software. But he should be able to depend on a staff qualified to advise him or to act in these matters. He and his associates should know also which technological applications have proved their worth, and which promising developments are imminent, whether in "older" media such as film or in new ones like the computer.

In instructional technology, as in other crucial aspects of educational management, the immediate need is for programs that will combine down-to-earth experience with formal training in appropriate disciplines. Various graduate schools of education are concerning themselves with this task, but their efforts must be multiplied and reinforced to make any real dent on the day-to-day management of the nation's educational institutions. Schools of business and public administration, architecture, and engineering should also participate. To this end, intensive efforts to establish management-training programs should be mounted by federal agencies in partnership with universities, school systems, state departments of education, and industry.

These management-training programs should command sufficient money to produce a marked improvement in the use of technology and in the way schools are managed. They could take many forms, including summer institutes, continuing seminars, and longer-term university internships and fellowships—all informed by constant feedback from the field.

One educational observer has suggested the creation of a "staff college for higher education executives," adding that top university officials "need both mirrors and windows—so that they can look inward as well as outward." The National Academy for School Executives' advanced seminars, which have devoted particular attention to instructional technology, point the way toward such a program for school administrators.[12] Clearly, the most promising of these programs now in operation or projected should be supported by the National Institute of Instructional Technology.

Sophisticated, practical *pre*-service management training is also essential. The immediate concentration of funds and ingenuity should, however, be on in-service training, since most administrators, especially in the lower schools, come up through teaching.

Teachers

There is evidence today that school teachers, a traditionally conservative group, are beginning to see the value of using technology for educational purposes. Lois V. Edinger, professor of education at the University of North Carolina, wrote to the Commission:

> The vast majority of the members of the teaching profession have accepted the fact (or in some cases simply become resigned to it) that education must leave the era of "hand labor" and turn to machines to help increase their productivity. That we must turn to the using of power tools in education to allow teachers to become more effective is a fact accepted by the teaching profession today, albeit with varying degrees of pleasure and readiness.

Dr. Edinger's words are of special significance since she is a recent past president of the National Education Association and undoubtedly expresses the view of many schoolteachers. It appears to be true, however, that most *college* teachers continue to resist the "inroads" of technology.

A central benefit (as well as prerequisite) of the comprehensive application of technology to education will be a more systematic approach to instruction. The role of the teacher needs to be more explicitly defined than ever before. The teacher, therefore, should understand the far-reaching implications of technology in order to function at his individual best as the central element of the total system. The base for this understanding should be laid in the teacher's

[12] The National Academy for School Executives is an adjunct of the American Association of School Administrators.

Planning for the development of instructional technology should include the recruitment of such nonprofessionals. As Professor Robert H. Anderson of the Harvard Graduate School of Education told the Commission:

> The emerging concept of auxiliary personnel in education has already created an impressive literature, which has recently begun to focus on the important topic of *training* auxiliary personnel. Not only can technology play an important role in the training of such workers, but it seems increasingly necessary for these people to be familiar with technology as an aspect of their work.

Whether a staff advisor in instructional technology is necessary might be disputed by those who have been discouraged by experiences with the typical audiovisual department of a school or college. It is the exceptional audiovisual department that is integrated into the fabric of the institution—with qualified audovisual consultants sitting in on courses, sharing in the teaching methods and environment, and then contributing to improvements through technology and otherwise.

Qualified specialists in the production of instructional materials are scarce. Producers, graphic artists, audio technicians, and programers are but a few of the professionals needed to develop maximum effectiveness in instruction. Lack of expert advice in the production of instructional television programs, for instance, has often produced mediocre results. All too little is known about how to present instructional material over television most effectively. Creative use of the medium has been barely attempted. There is no doubt that the "talking face" has been overdone in instructional television. But even this technique has its usefulness and could be made more effective. Outstanding lecturers who fail to come across over television could improve their performance on the screen with help from skilled professionals.

The scarcity of good programers for the teaching machine undoubtedly tempered the initial enthusiasm for this device, and may be seriously handicapping current efforts in the various modes of programed instruction. Training and financial support for production and programing specialists should have top priority.

Instructional Designers

The need for someone to work with teachers in their planning strategy as well as someone to help students in using libraries, data banks, or computers to their best advantage, is apparent. Institutions could combine forces and share the services of one instructional technology advisor, who could also conduct research and development in "instructional design."

Research and development in education are dependent upon the interaction of specialists from many different fields. The meager success of research efforts to date can be attributed in part to the dearth of well-qualified research specialists. If research and development efforts are to be relevant and fruitful, they must enlist the participation of behavioral scientists, subject-matter scholars, engineers, educators, and others. The central figure in this "mix" may well be an instructional designer, whose role Robert Glaser has described as follows.

> It is highly probable that a unique occupational specialty called instructional design will emerge in view of the current level of heightened interaction among educators, behavioral scientists, educational publishers, electronics and com-

puter industries, and R & D organizations in educational technology. This specialty will involve a person or group of persons concerned with the production of educational procedures, materials, and systems.

Instructional designers need to pick off appropriate research and development activities from behavioral science knowledge, and behavioral scientists need to pay attention to the fundamental problems generated from attempts at technology. From this interplay there will emerge a body of pedagogical principles or a technology of instruction that will be fundamental to the task of instructional design.

As educational systems incorporate more of the advances of science and technology into their design, the specialty of instructional design will grow, and there will probably be many different sub-specialties; for example, applied research and development, operational materials design, computer systems, teacher practices, language and linguistics, preschool learning, etc.

Instructional designers in applied research, development, and production capacities will be in increasing demand in the near future. Indeed, at the present time, such persons are rare and eagerly sought.

Recommendation No. 6

WE RECOMMEND:

The National Institute of Instructional Technology should take the lead in bringing businessmen and educators together in a close working relationship to advance the productivity of education through technology.

To this end, the National Institute of Instructional Technology should consult with other interested organizations and develop an appropriate mechanism. A possible course of action, for example, could be the establishment of a National Council of Education and Industry that would focus on how technology can best meet the needs of individual students, teachers, and administrators. A small high-level council of this nature, with representatives from key branches of education and the education industry, could help speed appropriate advances in the design, development, and application of technology to instruction.

The free marketplace for materials and equipment has generated great benefits in education, as in other sectors of American society. However, there is increasing realization today that in the major fields of social service, such as medicine, the operation of the free market must be supplemented by some mechanism to make sure that innovation and diversity are encouraged, quality maintained and enhanced, and the most urgent social goals achieved. Education lags behind other fields in providing help to practitioners in making wise choices among competing products, and in spelling out its precise needs.

Until a decade ago, the "education industry" was virtually synonymous with textbook publishing. Then, as substantial new federal funds became available for the purchase of newer kinds of equipment and materials, publishers began, through acquisition or expansion, to branch out into various areas of instructional technology. But the central fact remains that the school and college budget for equipment and materials is still relatively small.

What is called for is a closer scrutiny of the process by which machines and programs have been developed and marketed. Educators have played little or no part in developing new products. They have not been informed on a regular basis of recent developments, nor has industry devised an adequate process for obtaining their advice and counsel. When new equipment comes on the market, many educators are in the dark about the advantages and disadvantages of the various options offered and are at the mercy of sales propaganda and rhetoric. Thus many purchases made by schools and colleges have been inappropriate and premature. On the other hand, educators themselves have not always demonstrated a realistic understanding of technology's potential for instruction, nor of industry's problems in meeting educational needs.

In general, these conditions obtain today:

- Many technological devices offered to educators are designed mainly for uses other than educational; this drawback applies particularly to the computer, which needs distinctive features to be wholly adaptable to education (for example, larger memory capacity, greater simplicity, and better display capabilities).
- Equipment prices are geared to what the *commercial* market can bear; there has been no concerted attempt to bring them down to levels acceptable to education and the taxpayers who support it. Most schools and colleges simply cannot afford needed equipment.
- Many institutions lack equipment they need (e.g., television, computers). Some are overstocked with equipment (e.g., movie projectors, overhead projectors) which is largely unused or seriously underused; in many cases the equipment on hand is fast becoming obsolete and constitutes a serious barrier to the acquisition of new improved devices.
- Instructional material to stoke promising devices is inadequate; new hardware comes to the market years before enough worthwhile programs are ready to meet school and college needs.
- The quality of most of the software that *has* been developed is relatively poor. The problem is insufficient money and talent for the concentrated effort required to produce good materials.
- Material is often limited to use on a machine of one particular make. For example, one company's videotape recorder will not take another company's tapes. Until a solution can be found to the problem of incompatibility of equipment and programs, the effectiveness of instructional technology will be correspondingly retarded.
- As indicated earlier in this report, many technological devices are too complex for teachers to use readily and often. When breakdowns occur, repairmen are not immediately available. Maintenance is a serious problem; lack of funds and manpower often renders equipment unusable.
- Field testing of new devices before they come on the market is minimal. As a result, educators receive little validated evidence on which to base their purchasing decisions.

In short, educators at present who do not suffer from lack of equipment often suffer from having too much obsolete or unused equipment, or the wrong kind of equipment, or equipment with insufficient good software, or incompatible equipment, or equipment too complex for proper maintenance.

A close new working relationship between industry and education should be possible if each group actively demonstrates its willingness to cooperate, to understand the other's problems, and to make necessary compromises.

For this essential cooperation of education and industry to bear fruit, certain changes in attitude and approach are required.

For instance, *industry* must be willing—

- To forego immediate profits, to concentrate on development of equipment and materials for the long run, and to abandon the belief that because a product sells well, it is educationally sound. (Since the market for educational materials is still relatively small, sustained development by industry may well require federal pump priming.)
- To develop intensively a limited number of products which have proven effective for instructional purposes; and to work toward solving the incompatibility problem.
- To work with teachers, administrators, and students in the development and redevelopment of materials and equipment.

Educators, for their part, must be willing—

- To define instructional objectives clearly enough so that materials and equipment can be produced to meet them, and then to use items produced that meet these specifications.
- To help test new devices and to persevere with innovations until they can be properly evaluated.
- To acquire the necessary understanding of technological innovations and develop sound methods for measuring their capabilities.

The Commission believes that a mechanism should be created to initiate and cultivate such a cooperative effort. We therefore recommend that the National Institute of Instructional Technology take the lead in establishing an effective group to carry out these objectives. One mechanism would be a small strong, high-level national council, with representatives from key branches of education and the education industry. In setting up an appropriate and forceful group of this order, the NIIT should work with organizations such as the Corporation for Public Broadcasting, the Educational Media Council, the American Textbook Publishers Institute, the Education Commission of the States, the Joint Council on Educational Telecommunications, the American Library Association, state departments of education, the National Association of Educational Broadcasters, and the National Audio-Visual Association. Through constant feedback from the field (teachers, administrators, salesmen, managers), a council of this sort could keep in touch with new and persistent problems and with the most promising lines of product development.

An organization representing education and industry should develop and institute improvements in the design, development, maintenance, and utilization of instructional technology. The functions of such a group would include:

(1) The establishment of standards for instructional equipment.

(2) Concerted action to meet the specific needs of schools and colleges.

(3) The development of practical methods to make equipment and materials compatible.

(4) The establishment of a mechanism—perhaps a clearinghouse—to provide education's managers with comparative operating and economic data on technological instruments and systems designed for administrative as well as instructional purposes.

(5) Initiating or improving laws and regulations affecting instructional technology (e.g., copyright laws, satellite controls, reduced rates for long-distance educational communication).

(6) Active cooperation with the National Institute of Instructional Technology in devising ways of directing federal and private funds toward the production of high-quality instructional materials.

(7) Exploration of new methods for providing school districts with funds for instructional technology, including the possibility of leasing or renting equipment, or the purchase of equipment on a "pay-as-you-go" basis.

(8) Active cooperation with educational institutions, under National Institute of Instructional Technology leadership, in establishing practical programs to train and retrain the managers of education.

APPENDIX 5

2/

EDUCATION AS AN INFORMATION SYSTEM

George Kozmetsky[1]

Mr. Chairman, members of the Committee, I am honored to have this opportunity to appear before you on a subject as vital to our Nation as Education for a Changing World. Our subject matter can best be exemplified from a management point of view by the quotation: "For a manager, a lifetime of experience is no longer enough." Nor is a "lifelong learning" sufficient without relevant experience. Managers must have the ability to learn by analogs in a continuous process from formal education to experience and from experience back to formal education as well as through personal learning interrelated by communications within a network of reality. In this manner, we can visualize education as a "continuous process" involved with multi-faceted information systems that permit tomorrow's managers to stay abreast with or even enter into a varied multi-career.

There are no higher education institutions for the development of managers with multi-careers, or courses for such innovative management. And if one were referring to the kind of management required over the last third of this century and the first quarter of the 21st Century, then there are very few, if any, universities concerned with the problems. Yet it is becoming one of the great socio-economic-cultural requirements of our day.

One must, at this point, be personal. In September 1966, when I assumed the deanship of the Graduate School of Business at The University of Texas at Austin, it was my dream to develop an educational program for the American manager of the 21st Century. In the pursuit of this goal, I have kept uppermost in mind the explicit caveat of Harold Laski: "When the leaders of a people ask their followers to die for a dream, those followers have a right to know in whose behalf the dream is being dreamt."

More specifically, as a Dean and a hopefully dedicated citizen, I established for the college the following guiding objectives:

In order to become one of the best colleges of business in the nation, at least two very fundamental requirements must be met. First, the college must have its own objectives which are achievable and which reflect primarily the needs of its students while at the same time recognizing the development needs of its faculty, its society, as well as government and industry. Second, the way in which the college initiates its objectives will to a large measure determine if it will successfully meet them.

The objective of the Graduate School of Business is to train the managers of the last third of the 20th Century. More specifically, the college must educate the future managers of the technical and intellectual resources of our nation. This charge is an extensive one which challenges all of the college's ingenuity and resources.

[1] Dean, College of Business Administration and Graduate School of Business, University of Texas.

2/ U.S. Congress. House. Committee on Science and Astronautics. Management of Information and Knowledge. Committee Print, (91st Congress, 1st session) 1970. 130 p. A compilation of papers prepared for the meeting of the panel of Science and Technology.

A quick reflection about the future brings the magnitude of this challenge into clearer focus. Managers for the last third of this century must: deal with emotional and behavioral as well as technical changes; learn to converse in the appropriate language of mathematics; communicate with and manage scientists, engineers, accountants, and artists; use sophisticated new tools for effective planning and controlling strategic and tactical decision making; and understand and implement the social and individual value system of our nation. In essence, the managers of the last third of this century must be cross-disciplinary and must embrace new methods and techniques.

This presentation includes the more relevant experiences, accomplishments, and researches to date of the faculty, students, and my colleagues at The University of Texas and other institutions with whom we have collaborated. I would be remiss not to mention my gratitude to a great many individuals who have helped shape the thoughts and ideas reflected herein. A complete listing is impossible; however, among those at The University of Texas at Austin who have had particular influence are Professors Eugene Konecci, Floyd Brandt, Abraham Charnes, Lanier Cox, Lawrence Crum, Edward Cundiff, David Huff, Gaylord Jentz, Judson Neff, Albert Shapero, C. Aubrey Smith, Burnard Sord, Tom Tucker, Ernest Walker, and Glenn Welsch. My academic mentors of the past including Professors G. I. Butterbaugh, Ed Learned, and Georges Doriot provided me with the necessary academic foundation. My associates in academic and industrial research include W. W. Cooper, Herbert A. Simon, C. B. "Tex" Thornton, Roy L. Ash, David Learner, and Henry E. Singleton; they gave me inspiration to approach in a direct, systematic and pragmatic manner the problems under discussion. Equally I am grateful for the assistance and close collaboration of Carl Mueller, Bud Coyle, Fayez Sarofim Jim Bayless, and Arthur Rock for the insights gained for relevant entrepreneurship formations for tomorrow's industrial society.

Systems Analysis for Integrative Higher Education Planning

Today educators are facing relatively the same question asked by Professor George Counts of Teachers College in the 1930s, "Dare the Schools Build a New Social Order?" Let us pause for a moment to review quickly the change in higher education philosophy since the 1930's. It became somewhat clear to educators between 1939–45 that the armed forces needed high mental capability as contrasted to physical capability. This was reinforced in the post-war period. It is clear that our military-industrial complex requires increasing levels of intellectual capabilities as well as an understanding of science and technology. The practitioners of the futuristic art have already heralded the need for the extension of these more technical skills in order for our nation to enter tomorrow's meaningful community of humanity.

The above causes have, in turn, had their effect on higher education. Their early manifestations were the stress upon excellence in education through excellent teachers and excellent students. Our universities directed their changes towards tougher academic entrance standards for their professorial staff as well as for students. They initiated and maintained more academic specialization, especially at the graduate levels. Qualitatively, the faculties emphasized depth knowledge;

quantitatively, the faculties increased the scope and amount of reading expected from their students. Research by individual faculty, individually selected and sponsored by government or foundation grants, prospered until it became relevant to discuss "publish or perish." All of these were the effects of an increased emphasis on excellence as a standard for our community of scholars—student body and faculty. The accomplishment of the sum total of these reforms was that between 1950–1965 our universities turned out over 4 million graduates, which was almost 80% of all college graduates turned out up to 1950.

The quest for excellence in education between 1945–1959 had some negative side effects. Frank G. Jennings stated these as follows:

"They hunted out the gifted child and tried to hound him into competence. They began to rescue physics from the scrawny hand of Newtonian mechanics and cradle it in the nucleus of the atom. They redressed mathematics in properly regal garments, threw away the abacus, and plugged in the computer. They sought good young minds everywhere and found them most often among the well-fed, the well-born, and the fair-skinned."[1]

On the other hand, the quest for excellence in education between 1945–1959 has had, in my opinion, some positive benefits. The first of these was that it provided for education a goal of leadership in our society—to lead it, not follow it. This was succinctly stated by Professor Sterling M. McMurrin as follows:

"Our society is marked by scientific intelligence, social conscience, and an acute historical consciousness; it possesses a remarkable capacity for invention and change. Since for us change is inevitable, unless we move forward with resolution our society is in danger of retrogression and our culture in danger of decline. We cannot live simply by the conservation and perpetuation of the past; we must be critical and creative.

"The proper function of schools, therefore, is to be the chief agents of progress, whether it is the advancement of knowledge, improvement in the arts, technology, or the social conscience, in institutional organization and administration, or in the attainment of those large visions of the future which are the prime movers of history. For the schools, colleges, and universities provide the most effective means for the achievement of the intellectual skill, knowledge, understanding, and appreciation necessary to the analysis, judgment, and decision without which there can be no genuine progress. We depend upon them to stimulate that freshness of ways, attitudes, and ideas which alone can bring vitality and high achievement to a culture."[2]

So accepted has this objective become since the times of Professor Counts' challenging speech that when the American Academy of Arts and Science Commission on the Year 2000 was meeting, there was general agreement with Dr. Herman Kahn's statement:

"Let us assume that it does not take much time or effort to worry about internal order, international order, national security, or material goods. I submit [then] that the main motives for our going to school would then disappear."[3]

---

[1] Frank G. Jennings. "It Didn't Start With Sputnik." *Saturday Review*, September 16, 1967, p. 97.

[2] Sterling M. McMurrin. "What Tasks for the Schools?" *Saturday Review*, January 14, 1967 p 40

[3] Herman Kahn, "Working Session I: Baselines for the Future, October 22–24, 1965" Richmond, Virginia: American Academy of Arts and Sciences, 1967, p. 674.

As we turn to the 1970s, educators are once again faced with "Dare the Schools Build a New Social Order?" We are aware that a quest for excellence in education as promulgated was at best a short-run objective. The advance of technology in our society already demands all levels of intellectual talent for building the industrial society emerging from the second industrial revolution. The requirements of our "nonroutine industries" as contrasted to the "mass production industries" will require over 60% of our productive population in the year 2000, or a work force equal to the 80 million we have today. From a philosophical point of view, Whitehead reminded us a long time ago that: "in the conditions of modern life the rule is absolute. The race which does not value trained intelligence is doomed." Intelligence is not measured solely by intelligence quotient. That was well known to the educator in the 1930s. In today's idiom and in a very pragmatic sense, we can no longer discriminate on the basis of race, color, creed, or intelliegnce quotient. In economic terms, our nation has an inelastic supply of people to meet their ever-increasing demands. In a philosophic sense, education must enable every person to develop to the fullest whatever he has in him to become. In short, there is no conflict between what so many think are firmly inflexible or polarized needs of our society.

The transition towards these goals will not be easy; yet in some respects it will be much easier than that experienced from 1952–1969. The past five years have seen educators delineate the basic assumptions which will become the base upon which the new and enriched standards for education of the 1970's will be structured. Challenges to seven basic assumptions of the previous generation of educators are being evolved:

In spite of all the above awareness and pressures for change, our principal problem in higher education is widespread, habitual, institutionalized resistance to needed change. My purpose is to discuss some new horizons that provide for the acceptance of change.

The application of systems concepts to all aspects of higher education is still in its infancy. By the same token there has been minimal application from the field of cybernetics to higher education even as an information system. Systems concepts and the other principles are found in all phases of scientific disciplines. Only recently have many of our institutions of higher learning become interested in their application to the university itself. This is only natural, for the emphasis upon a systems methodology has come from both the sciences themselves and the double-barreled major thrust of modern industry's development and recognition of many of our social and economic problems. These thrusts, which in turn have made possible the explorative system methodologies and the creation of principles, techniques, and tools for their partial solution, have provided the main impetus for considering education as an information system.

Higher education's approach in the past, and at the present, has been to do research in bits and pieces and to incorporate the results into the curriculum on a piecemeal basis. When viewed from the application of communication and information principles, such research commingled the data and information so that it covered the need to identify clearly the additions from research to the current state of the art, the advances in techniques or in the processes of teaching, and the advances in the learning process by the student. This method has three significant drawbacks. First, current instructional methodologies are often inadequate vehicles for the transmission of the product of research. Conventional teaching methods in the area of management decision-making, for example, do not lend themselves well to the teaching of the newly developed techniques of modeling. Such techniques are best taught in a curriculum where the conversational use of computer is an integral part of the instructional methodology. Second, current modes of curriculum change yield curricula that may have certain outstanding areas; but, when viewed from the perspective of systems analysis, rarely exhibit a coherent structure and are often plagued by inadequacies and redundancies. Third, the time required to transfer the relevant findings of research to specific areas of knowledge and/or technique with the appropriate method of teaching a specific course is so extensive that often it is outdated by newer research before it is utilized.

During the past two years, Dr. Thomas Burke had been Special Research Associate at The University of Texas at Austin and worked on "A Systems Approach to the Planning and Formulation of Technology-Augmented Programs for Management Education." His research resulted in the definition of two main needs in order to develop new curricula and courses using new technology in its teaching by the educator:

> (1) An educational approach for the practicing professor who, while perhaps untrained in computer applications for teaching, is seriously interested in upgrading his ability to recognize and put to work improved practices which exploit the full potential of technology such as that provided by the computer.
>
> (2) A curriculum framework or perspective for use by management faculty and/or administration in the identification, evaluation, and incorporation of innovative subject matter into the curriculum.[4]

By now it is clear that systems analysis can be used for the development of integrative curricula. The problem of developing effective curricula relative to teaching resources, research, data gathering, and physical resources suggests an enormous field of inquiry. However, it is the integration of the forces of curricula change, of restructuring our colleges and schools, and of their required resources that is mandatory for tomorrow's society.

Innovative Management Under Creative Capitalism

When Neil Armstrong took that giant step for mankind, he opened the scene for a better society on planet Earth. Something greater than a step on the moon happened on that historic day. On July 20, 1969, the curtain rang down on the "*First Industrial Revolution*" of the past two centuries and the stage was set for the transition towards an "*innovative socio-technological era.*"

The economic and political success of the United States has been in part due to its "traditional 'capitalistic' [and democratic] factors as sufficient flexibility to accommodate entrepreneurship and a fundamental belief in the value of individual initiative and free competition."[5] Capitalism as a philosophy has gone through at least several phases in the United States. The famous business historian, Professor Norman De Gras, had delineated these phases in terms of "financial capitalism" to cover the period of U.S. business growth from the

[4] T. E. Burke "A Systems Approach to Planning and Formulation of Technology Augmented Programs for Management Education" (Ph. D dissertation, the University of Texas at Austin 1969) p 130

[5] Robin Marris "The Role of the 'Business Like' Organization in the Technology of Social Change" *Social Innovation in the City*, ed by R S Rosenbloom and R Marris Cambridge, Mass Harvard University Press, 1969, p 2.

1860s to the 1930s and "national capitalism" to cover the period from the 1930s. The first period relied on private capital first from outside the United States and, in later times, to internal United States private financial institutions. The shortcomings of "financial capitalism" led to what many of us in this room lived through as the "Great Depression." The second period was more of a reliance upon federal sources for financing or government guarantees and extensive use of private management. In fact, the major concentration of this second period has been a dramatic partnership between the federal government and private enterprise to prevent the "scourge of depressions." The successes of this partnership in terms of historical "national capitalism" have been legendary. They have made our nation economically affluent and thrust our nation into the forefront of world political powers.

Success at a national level too often, as at a personal level, lays the seeds for unforeseen possible problems. Today it is clear that "national capitalism" has been deficient in two respects. The first of these is that it has resulted in the United States' creating and exhausting from 40% to 60% of the total world wealth with only 6% of the total population. The second is that national capitalism has, by its very success, dulled our ability to react to the existence—and their timely prevention within the nation—of underprivileged classes, urban crises, pollution, crime, a rising group of lost youths, an emerging new left, and insufficient regard to our more rural areas and their transitional problems into tomorrow's industrial society. In short then, the deficiencies of national capitalism have created the need for what I call "creative capitalism" based on innovative private management.

Today many believe that our social problems are those of crime prevention, pollution, urbanization, poverty, employment of youth, and determination of a stalemated peace. Yet in many respects these are symptoms of the unsolved problems that emerged from an aging, maturing, and declining phase of the First Industrial Revolution. This is not to say that these are not important problems for our present society. They are. However, concentration of a majority of our intellectual resources on these problems to the extent that we ignore those based upon the predictable advances of the Second Industrial Revolution will permit newer problems to arise as continued crises too often wrapped in protest for immediate solution. Such problems of transition were succinctly stated in an editorial of the *Economist:*

"What has happened in France this month ought to nag at the minds of people who are concerned at the way the world's industrial societies are developing. The crisis in France has raised expectations in countries which, though they are rich by the world's standards, are not rich enough to match the rocketing demands of their people. It has also raised the problem of completing the transition from an oligarchic society to a democratic one in a world where efficiency demands that life be organized in large units. These are problems for both communists and democrats." [6]

To this may be added a statement from an editorial which appeared in the June 12, 1968, issue of the Austin *American-Statesman:*

"Our professions, our schools, our fiscal and financial institutions, and all our agencies of government face a double crisis. The demands upon them are increasing in scale and changing in quality at the same time. Only the overhaul and redesign of the institutions themselves can give them a fighting chance to keep pace with the human needs they are trying to meet." [7]

[6] *The Economist*, May 25–31, 1968, p. 8.
[7] David S. Broder, "The Need for Institutional Change," *American-Statesman*, June 12, 1968, p. 4.

Technology, science, and formal education are not enough, in my opinion, to solve these fundamental needs. The impact of continued automation is familiar to all of us. They range from the concern of the human use of the individual to the concern of the continued economic growth of our 500 largest corporations. Mass production two decades ago made it possible to create as the high-income earners the self employed: professional, small businessman, and farmer. Today automated mass production has changed the mix of this group to salaried executives, scientists, engineers, and other professionals.

In short, we are witnessing a relative decline of mass production requirement tasks for employment. The routine requirements of the past two-thirds of this century are rapidly being replaced by machines. To date much of our educational system has been geared to educate and develop people for an industrial society which can be generalized as "routinized" or mass productive.

The task that the last third of the 20th Century industrial state imposes on our educational system is the increasing development of people for nonroutine tasks under "creative capitalism." Particularly since World War II we have seen the rise in what we could call the technological industry, which is concerned with "nonroutinized" kinds of problems and demands that require a new order of solution. These problems are concerned with space exploitation, buildings of megalopolis, control of environment, water and air pollution, marine sciences, crime, transportation, and environmental health.

As stated earlier, these areas provide the bases for an expanding nonroutine industry of the next decade or two. On the other hand, the innovative management is aware that the problems of the Second Industrial or Socio-Economic-Cultural Revolution also provide opportunities. Cybernetics as a science has yet to delineate clearly and specify these opportunities. What are some of these yet unexposed problems that only man can identify as problems?

(1) What will be the 21st Century industries in the United States? How will their development be financed? What will be their markets?

(2) Leisure as an industry is not only in its infancy but is not yet clearly delineated. During the transition to the 21st Century, there will be four types to satisfy the following groups: first, the unemployed (waiting between jobs); second, the low-salaried employees working short hours; third, the higher-salaried groups working short hours; and fourth, the professionals (including statesmen) working long hours and who will have limited leisure in sporadic bursts.

(3) When will a black cease being a black?

(4) How do you redistribute the wealth under "creative capitalism"?

(5) How do you allocate the abundant resources—short run, long run?

(6) How will new forms of organizations change the institutions to fit the social and individual needs?

We have witnessed the advent of technology to newer industries such as nuclear energy, aerospace, and petrochemical and, thereby, have witnessed emerging industries for nonroutine activities. These nonroutine industries have given employment to more people at all levels of our society at a faster rate than possible in the mass-production industries. The nonroutine economic activities are characterized as follows:

1. They are technically based, and their products have a relatively high proportion of technical and professional labor in the final product.
2. There is a continuous shift of the high technical content within the activity from the final product to its tooling or processing.
3. The number of final units is not larger; in fact, it can range from "one of a kind" to what would be generally recognized as a "short production" run.
4. The problems and processes involved can be typified as "messy." That is, there are no single clear-cut solutions including scientific and engineering principles. Often, so-to-speak solutions must be "invented" on the spot.

5. The nonroutine activities thereby utilize large quantities of intellectual capacities; e.g., people ranging from semi-trained technicians and laborers to noted scientists—social as well as physical.
6. The management of these nonroutine activities often requires the full coordination of government, universities, and industry. However it is generally recognized that industry has a major role to play in the economic exploitation of these technological advances.
7. Finally, the ability and capacity of our management of these technological and intellectual resources will determine to a large measure whether our nation will continue to increase its advantages in the nonroutine activities. The reason is that some technologies are more currently available and enjoy a higher probability of success over others; in addition, each has its own costs associated with it in terms of research and development, tooling, product costs, distribution and marketing, service and maintenance, as well as its social costs of retraining, dislocation, and expansion of our urban and rural areas.

There are, however, two underlying requirements to all these "nonroutine" pursuits. First, they demand large quanta of technical and intellectual resources such as individual scientists—social and physical—engineers, and other professionals and service personnel and technicians as aides to the professionals. Second, they require relevant and up-to-date information necessary for the solution of the nonroutine problems. Of course, the key requirement is managers with the ability to identify and formulate the problems for solution.

Any approach we may make for meeting the tasks required for the nonrepetitive problems brings sharp changes in the economic, social, and political environment surrounding the conduct and management of these resources. There are good reasons for this. Our society does realize that our intellectual resources are in short supply. Furthermore, the scarcity of intellectual resources is not only recognized by industry and government but there is an awareness that their supply is relatively inelastic.

In short, technological change has set up a self-amplifying system in its demands for intellectual resources. Technology generates new advancements which, in turn, generate still greater need for sophisticated intelligence and action. The task for management education is not merely to select the gifted or excellent student for training but to develop on a broad front all levels of skills to meet the requirements of society in developing people for all their roles in a society which are essential for the full cultivation of each individual's talents and abilities.

An easy way to summarize the employment needs of our society in the last third of the century is shown on Table 1. (Please note that the data herein are, at best, estimates.)

TABLE 1.—ESTIMATED PROJECTIONS FOR RELATIVE WORK-FORCE REQUIREMENTS EXPRESSED AS PERCENTAGE OF WORK FORCE

[In percent]

	1860	1968	2001
Agriculture	90	10	5
Mass production and service industries	9	70	30
"Nonroutine industries"	1	20	65

The problem for today's education is to develop innovative management that can take intelligent action to solve the cumulative consequences of continuing rapid technological change, economic growth, urbanization, and continuing deescalation of rural areas in a way that provides for a renewed democratic society in a context of "creative capitalism." Another way of saying this is to repeat the late President John F. Kennedy's call in his inaugural address to confront the "unfinished business of our generation." No rhetoric alone can solve these problems. Nor may it be possible for any one of our 19th Century institutions to solve these problems alone. The 1950s and 1960s saw the growth of a new complex that was instrumental in solving many of our defense, space, and nuclear energy national problems; namely, the Federal government, university, and private enterprise complexes. Their potential problems were clearly stated by the late President D. Eisenhower in his farewell address. The 1970s and 1980s could well see the rise of a broader set of complexes which would include not only the Federal government but also local government entities; not only universities but also graduate centers; not only private enterprises as represented in the urban home offices and plants but also in their local plants found in the rural areas supplemented by emerging new firms that utilize the local resources relative to the economic utilization of advanced technology. In many respects, "creative capitalism" can well be institutionalized on these more broader-based complexes.

Creative capitalism must advance our society beyond the need for imperialism or exploitation of people. Creative capitalism's success depends on its creation of wealth in a manner that truly establishes the community of humanity as the goal of our society. Wealth produced under creative capitalism must be distributed in a manner which makes it possible to increase the standard of living of all the people in the world. The new institutions or complexes upon which creative capitalism is based will make it possible to solve in a timely basis our social problems simultaneously while creating wealth and providing for meaningful leisure for all people in the world. Education for creative capitalism thereby provides a challenge as well as an unprecedented opportunity for innovative management of all public and private institutions. Thereby education contributes and receives from experience a continuous process of developing a socio-economic-cultural society while developing the required knowledge of information for transmission to the coming generation.

Knowledge and information for development of innovative management under "creative capitalism" does not exist. In this respect, education today resembles a research and development organization which is geared for change. Professor Albert Shapero described the problem as follows:

"It is almost as if we were now in the position of those who began to develop our present body of management knowledge at the turn of the century. We have some skillful practitioners and some artistry, but do not have anything that can pass as an organized body of management knowledge relevant to R & D and the other growing areas of commitment in which technical and intellectual resources play a dominant part. We have a powerful and growing awareness of need for this kind of knowledge in order to cope with the problems that

are crowding us now and that can only increase in importance in the future."[8]

Herein lies the opportunity and needs for education for a changing world. The body of knowledge for transmission lies somewhat in our current materials in basic research of the past and present and in other governmental and industrial institutions although not published or partially published. The education needs are to develop principles of relevances to identify and extend such information. Teaching while developing an integrated body of relevant knowledge is a requirement for which education has no past experiences to fall back on. Simple solutions such as new techniques of multi-media, computer simulation, computer time sharing, and of computer augmentation while advances and often necessary are at best tools that can be used once the body of relevant knowledge is identified. For in the parlance of the computer profession, "garbage in, garbage out." More apropos are the remarks of the famous philosopher Alfred North Whitehead, "that the role of progress is such that individual human being of ordinary length of life will be called upon to face novel situations which find no parallel in his past. The fixed person, for the fixed duties who in older societies was such a godsend in the future, will be a public danger."

The development of the concept of innovative management identification and transmission of data is an example of education in a changing world. Several years ago, I spent endless hours searching through literature for concepts in this field to little avail. Computerization would have helped to reduce the search time but only in the sense that it would have identified a large number of possible books and articles. However my personal acquaintance with H. Igor Ansoff, Dean of the Graduate School of Business at Vanderbilt, quickly reduced the search time, as he has devoted a lifetime to the academic and practical aspects of innovative management. He quickly identified a workable concept that he was developing at the time. More specifically, he stated:

"*Entrepreneurial Planning.*—In this advanced stage, the firm sets corporate objectives, examines its strengths and weaknesses, probes deeply for external threats and opportunities, and—combining all of these—makes a systematic evaluation of its prospects. Any proposals for change undergo intensive search and analysis, culminating in an action decision, which then enters the flow pattern established in earlier stages of planning. Entrepreneurial Planning represents a major commitment of the firm's resources and top management time and can altogether alter the organization and atmosphere of the company.

[8] Albert Shapero, "The Management of Technical and Intellectual Resources," Working Paper, Graduate School of Business, the University of Texas at Austin, 1968

"This stage-of-growth analysis of management functions suggests several changing roles for the planner as planning evolves in the firm. Further, since the essence of advanced planning is organized entrepreneurship, the planner's job can be viewed as helping to provide the firm—through marshaling its full resources—with the nine types of talent that mark the entrepreneurial genius."[9]

Trying to abstract information on entrepreneurship and principles from the state of knowledge is a difficult task. While entrepreneurship has held fascination for the individual in terms of the American dream of being "in business for one's self," it has also been an area for research and study for over 150 years by economists and social historians. Yet there is little research work published and an extreme paucity of theory of entrepreneurship as it pertains to company formations and growth.

In view of a changing society, it is important that we review the concept of entrepreneurship particularly as it relates to nontechnical company formation and to technical company formation. The contention of this presentation has been that not only are their requirements entirely different but also the trend toward nonroutine industry requires changes in business entrepreneurship as well as changes in all institutions including education that nurture and supplement them. The entrepreneurs who have been interested in nonroutine ventures have characteristics and needs far different than those who are interested in ventures that are more concerned with technological products or services.

It is possible for the professor to develop knowledge together with the student. In the case of entrepreneurship, Dr. Susbauer devoted his effort with a faculty committee to explore the technical company formation process.[10] His doctoral dissertation is an outstanding review of the literature and clearly discloses the lack of knowledge of company formations in both nontechnical and technical companies. There has been little cohesive research in looking for the problems and thereby distilling the principles for entrepreneurship. His thesis showed that specific data could be gathered and maintained on technical company formations in the city of Austin, Texas. However, unless subsequently interested doctoral candidates write their theses in this area, the knowledge so gained will cease as of 1967.

Dilemmas Facing Education

At this point we can look more closely at the major dilemmas facing education. The first of these arises from the fact that our educational administrators are truly managers of our society's intellectual resources. These intellectual resources consist of the students who are in inelastic supply and the teachers who will be in scarcer supply because of the increasing future demands by industry and government.

There are today 50 million students in school and they represent 90% of our school-age population. In the next decade there will be 11 million children who cannot read or write; 7 million will not complete high school; and 2 million will drop out before they reach high school. In this next decade 30 million boys and girls will be looking for jobs. Our dilemma is that our educational administrators have to establish the basis for educating the students for an industrial society which is

[9] H. Igor Ansoff, "The Evolution of Corporate Planning," Reprint No 342, Graduate School of Industrial Administration, Carnegie-Mellon University.

[10] J. C. Susbauer, "The Technical Company Formation Process: A Particular Aspect of Entrepreneurship." (Ph. D dissertation, the University of Texas at Austin, 1969).

rapidly changing. They do not have the time to analyze the new requirements or establish an integrated curriculum as the students progress from elementary school through higher education. Therefore there are required the means and process for collaboration between the systems of higher and secondary education, between leading scholars and teachers, and between graduate departments and undergraduate departments and the establishment of comparable standards of achievement of students. Finally, channels must be kept open to transfer the flow of technical information and innovation to the students from industry and government.

As managers of our education's intellectual resources, we face the predicament of shortages of teachers. Already we have seen that higher education at the undergraduate level cannot be staffed by full-time tenure staff. Teaching assistants and associates are utilized by most, if not all, universities—public and private. In the secondary schools we are using assistants to teachers for less skilled portions of teaching or for giving individual pupils attention. There is a profusion of experiments in team-teaching to utilize scarce teaching resources, in the use of teaching machines and electronic blackboards, and in educational television. There are yet to be adequately developed measures of teaching effectiveness for the last third of this century.

It is appropriate at this time to examine in some detail the use of the computers in education, more specifically business education. It is indeed a shock to realize that the impressive multimillion dollar computational facilities are often as not used to solve the same problems as were assigned under paper and pencil teaching days. Such usages of the computer more often than we like teach the students that they cannot accurately punch a deck of 100 cards after a half-dozen attempts. More surprising is that the problems assigned to the computers often can be solved by the students on today's modern electronic calculators in less than a quarter of the time spent in the modern computer labs modeling, programming, punching cards, debugging, and evaluating the quality of the results.

Since becoming Dean of the Graduate School of Business, at The University of Texas at Austin, I have discovered two concepts which are applicable to computer designers as well as to educators. The first is that both are equally reluctant to use the principles or techniques which they develop. For example, computer designers, as a class, do not like to use computers to design new computers. Nor do educators generally apply the principles of management they teach to their own problems. The second is that both professions are reluctant to predict the future. Computer designers and educators feel that they do not want to be put in the position to do long-range predictions for they may be held to it.

In industry one quickly learns that a manager has no excuse not to try to predict the future. In fact, the reward system is such that it attaches heavy penalities for errors or omissions; conversely, the rewards for partial success are also high. One cannot start to build a major new company within a five-to-ten-year period in the United States without trying to predict the future. Indeed, one cannot enter into the electronic computer industry by extending a current operation or beginning a new enterprise without trying to predict the future. The consequences are evident from following the financial fortunes of G.E. computers, Control Data, and Scientific Data Systems, among others.

No manager will give up his current noncomputerized or semi-computerized formal and informal management system for an untried "quantum jump" of an integrated management information system or "system" management on the computer. On the other hand, I do believe that providing the principles, methods, and technologies as well as the required training for those items which make these concepts relevant is a proper function of the schools of business. In other words, I believe that the schools of business if they are to provide leadership for our business communities must undertake to fulfill these tasks of evolving the future managers for business, including computerized management.

Many tools, techniques, practices as well as experiences exist to help us forecast the future trends and opportunities in the use of computers in business and business education. To make the longer term forecasts of trends in this paper, I have used the information system available to me as a manager and dean. There is no available digital computer, heuristic program, or cognitive processor machine to do the strategic planning required for such a talk today. On the other hand, I have used the results of my industrial computer applications as a base for extrapolations when they are applicable to either uses of today's computers or needs indicated for development of advanced mathematical and nonmathematical techniques, computer devices, as well as research in the better understanding of man-machine system in developing the top management of the future.

The role of computers in the future, in my opinion, is the result of applying current advances in research rather than depending upon startling, unpredictable breakthroughs. By extension of the current state of knowledge and current research efforts in the fields of (1) servo-mechanical control and computation and (2) management sciences or operations research for management planning and control, it is possible to make a number of useful predictions in the use of computers in business and thereby in education.

A useful starting point to establish the basis from which predictions will be made is found in examining trends of the past two decades. Twenty years ago the United States had entered the postwar period of the mid-'40s. The techniques and electronic devices used for purposes of war were being studied for peace-time applications. It was found that servo-mechanisms formerly used to direct anti-aircraft guns could be used for industrial controls—material handling, positioning of machine tools, and semiautomatic process sequencing. A newcomer at that time on the scene, the digital computer could provide a means to mechanize complex manipulative and control problems associated with automation.

By 1960 it turned out that it was not enough to merely recognize that elements of industry could be broken into the parts of a closed loop control system, such as structural units, sensor units, communication units, actuator units, and visual displays. It became apparent that any organic system, of which industry is one type, operated by virtue of something other than just simple feedback. Organic systems had to be examined in terms of the reasons for the functioning of the system. While these principles were set forth by Norbert Wiener in 1948, it took a number of military and nonmilitary systems applications to outline the practical problems of implementation.

Organic systems are characterized as manifesting in the broadest sense a form of intelligence. As such, their basic building blocks are people, machines, and their respective interfaces. How these elements are interrelated has been a continuous effort of study on the part of those working on complex systems projects. Most recently attention has turned to the problem of considering the interrelations between multiple weapon systems which must function in close coordination with each other. Here the problem is not one of optimizing any one system but designing sets of weapon systems which adequately assure our national defense posture. In their fundamental respects these studies are closely related to the managerial problems of giving order and significance to those found in some conglomerate industries or in larger national and international corporations.

The modern research in the areas of Management Sciences and Operations Research also dates from the post-World War II period. By 1960 practical applications of early research were being made in both military and industrial areas. However, the advanced research of today is predominantly focused on industrial applications and is being conducted principally in a few of the country's leading universities.

The need to understand the role of the manager in organic systems provided much of the impetus to perform advanced research in Management Sciences. Accomplishments to date have been significant. Advanced quantitative techniques which are applicable to management decision-making rely on the aid of digital computers. Management Sciences with the aid of computers have solved such problems as location of warehouses or plants, scheduling production and inventories, selecting stocks and bonds for investment portfolios, determining the best advertising media for a product, estimating acceptance of new products prior to their distribution, and finally, monitoring and controlling operations of a complex and continuous production system. Recent thinking indicates that the piecemeal application of Management Sciences to separate aspects of industrial problems is not enough.

One of the major thrusts for looking at organic wholes came from the application of computers to the development of integrated total management information systems. Other current research indicates that even more is required in terms of looking at the problem as an organic whole. By development of computerized total information systems, the interfaces between human decision-making with machines, market requirements, technical confidence in new product development and their successful introduction for a world market became evident. In addition, concepts and methods need to be developed that will enable the procedures to be formed for the establishment of over-all company policy goals and subgoals. Advanced techniques of an analytical nature are required before it is possible to minimize the usual corporate drives which operate through techniques of compromise, conflict, and occasional corporation.

There is work going on in the research laboratory for new methodology on the conceptual level and on computer models as well as various display devices. This is one of the reasons why schools of business can play such an important role in the development of computer applications in business. There is need for stating requirements of top management so that they can be executed in meaningful devices that meet the flexible needs of executives.

Research as to how to present meaningful management action reports is required. One cannot help but speculate that some of the action reports should be given directly to other machines by the computers while others come to management attention. To the best of my knowledge, there is still no truly cross-disciplinary research group for display of information to top management. Schools of business, colleges of engineering, psychology departments, and mathematical departments can help to do basic research in this area. In fact, such cross-disciplinary exchange is a requirement if colleges of business are to extend their training of management for the future through computers. However time sharing for faculty member research is one thing, but time sharing for class purposes is another.

In the future such uses of the computer will be more commonplace in all business and education. The key point is that top management must participate in the total planning of any major projects. They cannot wait for the various functions to bring each of their various alternatives and then try to relate each of these to select a major alternative for coordinating their companies. Model builders cannot build models without working with top management. Otherwise, they will build models that satisfy them. They will be elegant models, but they may not be solutions anywhere near what top management requires. Today management must learn to crawl in the skin of the model builder and the model builder in the skin of the manager. The computer is one tool which facilitates this process. In the future when our schools of business have trained the top management of the future, special staff modelers will cease to be required. Just as operations research groups have begun to be replaced by either becoming parts of the functional group or by taking over operational responsibility, so too will the computer modelers of the future.

The role of the leading business schools is to prepare this new breed of top managers so that they understand and have the know-how to build these computerized models. Our nation is currently in the midst of a management gap as well as an educational gap. Industry, especially the technically based, has developed managers only through limited experience. Their numbers are still too small to be effective in extending our nation's industrial leadership or continuing the rate of growth our companies require. The schools of business are lagging behind industry in this respect. They have yet to have on their faculties scientists, engineers, life scientists, etc., that are found in fair-sized projects in the technically based industries. While it is true there is much talk and excitement on our campuses about cross-disciplinary education in the future, there is little being done. Even when there is such cross-disciplinary education, such as at Texas, we have found that the computer is a bottleneck. A central computer facility for teaching and research becomes quickly over-scheduled, and delays extend for days if not weeks. Waiting for computer runs is not conducive to such cross-disciplinary research and teaching. We at Texas are in the process of establishing a separate computer facility for this class of research and teaching as we start a research project for an integrative curriculum to teach starting in 1975.

Computerized models do not obsolete faculty as is generally assumed. For example, at Texas a model was put into a computer in Los Angeles with terminal boards in Austin. After two days of training the faculty members, one of our current accounting classes used it to evaluate the cost procedures used and their method of estimation. Our production department used it to teach critical path programming. Our quantitative controls department used it for the teaching of chance-constrained programming. Our executive development program used it for teaching strategic planning. Our College of Engineering included it in their engineering executive program. Quite straightforwardly, the classroom use of computers for management training, as most academicians recognize, is in its infancy.

Management of technical industries and educators of management for these industries, however, cannot continue to wait for required breakthroughs or new curricula. Let me explain why I believe both managers and educators will need to use computers to expand their abilities before 1975 and will need to rely on expanding their conceptual abilities through the use of computers to process large amounts of information for their strategic and tactical decision making. The requirement for such an evolutionary step comes from the rate of technological growth and the resultant explosion of data. As our technology advance continues to increase exponentially, so does our body of knowledge. The university professors are not the only ones who have been publishing books and articles. Members of industry and government have also published profusely. Technical reports published by NASA alone number over 100,000 a year.

Let me try to relate the data explosion to the amount of reading one would have to do weekly in order to keep current with technology through published works. In 1900 the weekly stack of published material would be five feet high, one foot wide, and one foot long. In 1960, the weekly stack of published materials would be five feet high, one foot wide and sixty feet long. Predictions have shown that by the year 2000 the weekly reading stack will be five feet high, fifteen feet wide, and sixty feet long.

The current trend of computer application to bibliographical search microfilming, microfilm cards, print reading, linguistics and library sciences does help narrow the transference of technical data gap. Even under the most optimistic of claims, it does little more than reduce the average search time for managers of technical industries, or their staffs, or the educators of management of technology from one hour a day to perhaps 15 minutes a day. Evaluation of studies made by NSF and Case Institute on what professional people do with their time discloses that the resultant savings of 45 minutes can be used to increase the normal four hours of reading and three hours of work for a normal eight hour day. Microfilms of any sort, of computerized retrieval systems do little to reduce the reading time. Abstracts either in small or large print do not solve the managers' problems of extracting the required information for decision making or the educators' problems of extracting the required information for decision making or the educators' problems of teaching, individual research, or determining required research for graduate students.

The diffusion of technology by computers will be an extension of present day data banks and retrieval systems. The use of computers for diffusion of technology will be a step-by-step development. Transfers of technical information will first be done by getting people together from different disciplines and professions to mutually discuss their needs and thereby transmit their research and development results. In other words, it will at first be a "mood" operation rather than a "computer mode" operation, and computers will maintain cognizance of each individual's area of interest in research and development in biomedicine, nuclear energy, defense, space chemistry, etc. Cross-indexing of technieal interests at detail levels is not a difficult task. A next step could be that where information is extracted in an orderly fashion by technically trained personnel and filed in computers that are accessible to research and development experts, top management, as well as to educators through time shared computers. Another step would be to establish orderly informational systems for selected areas of technology so that there are acceptable hierarchies of information files that minimize extraction, communication and filing time.

At this point, it is appropriate to review the second dilemma faced by education. Namely, how do we come to grips with the economic and technological considerations in educating for the full development of the abilities of each individual? How do we evolve the education of individuals for both the mass production. repetitive industries and the technological, nonroutine problem industries? How do we bring the resources of the school into full effective use so that each student's capabilities are fully utilized?

One thing is clear: American parents and individuals will not let us say we cannot or we do not know how. We must organize research programs for increasing our teaching effectiveness. Teaching machines and other material technologies are only one means of doing this. Evolving social systems of permitting each student to develop at his own capacity may require provision of a large number of decentralized microfilm libraries. It may even change our methods of grading. The requirements are clear. Policies are fairly easy to enumerate. The implementation is not beyond our abilities, nor must the future of education be projected from present lines of development. In many respects, a simple extrapolation of today's developments would lead to agony. On the other hand, the future must be imagined; and therein lies the ecstasy.

APPENDIX 6 1/

REALIZING THE RADICAL RELATEDNESS OF TECHNOLOGY AND EDUCATION

(By P. Kenneth Komoski, President, Epie Institute, New York, N.Y.)

I am speaking to you out of a deep concern over the ways in which technology and education are related in the world today. This relationship may best be described as a dynamic interaction between two extremely potent forces. The question which concerns me most is how each of these powerful forces is currently shaping the other and, in so doing, is shaping the evolving world. This is an enormously broad question of profound importance. Nevertheless, I shall attempt to cast some light upon it in this brief presentation.

My first theme is that there is an urgent need to fully realize (in the sense of comprehend) the extent to which technology and education are related in the modern world. My second theme is that this relatedness exists at a very deep conceptual level and its practical everyday social and educational implications have hardly begun to be realized (in the sense of being made real). Needless to say, these practical implications are both positive and negative—but more importantly, they are also *unlimited*. At present, there is great difficulty in realizing (both in the sense of comprehending and making real) the implications of this relatedness because of our severely limited conceptualizations of technology and education. These limited conceptualizations have resulted in the widespread failure of educational policy makers, practitioners, and the public at large, to grasp the truly radical implications of the relatedness of technology and education. I shall focus first on our present limited concept of technology.

The most common and most limited of the current conceptualizations of technology is one which equates technology solely with machines. The defining attributes of this machine-centered conceptualization are efficiency and economy achieved through repetitive, standardized activities organized for the purpose of producing a standard, widely applicable result or product. When a person who adheres to this limited concept relates technology to education, he views it as a means of achieving a set of standard educational objectives via standardized techniques of instruction.

A second somewhat less limited conceptualization of technology is one in which technology is viewed as man's means of manipulating the elements of his material environment for the purpose of producing specific, consciously conceived results. When a person with this concept in mind views the relationship of technology and education, he sees little more than the use of various devices, such as film projectors, television, or the manipulation of various environmental elements such as walls, lighting and acoustics in order to achieve a set of educational results.

One reason why these conceptualizations of technology are uncomfortably limiting is their failure to take into account technologies that are neither machine-centered nor concerned solely with the manipulation of material elements of the environment. That is, they fail to make room for the newly emerging biological and behavioral technologies. But even if we enlarge the concept of technology to make room for these emerging technologies, we would only be engaging in a process of redefinition by addition. Whereas, what is urgently needed (if we are ever to comprehend modern technology and its relationship to modern education) is to undertake a fresh approach to the definition of technology built upon that which is *most basic* to all extant technologies—whether they be mechanical, electro-mechanical, electronic, biological or behavioral. What we should be striving for is, in fact, a radical redefinition of technology based on the most essential and common elements of all extant technologies.

Almost ten years ago, Walter Ong, a noted Jesuit scholar in the United States, suggested rather cryptically, that at its most fundamental and essential level "Technology has to do with the ordering of the possessions of the mind." This tantalizing insight into the essence of technology takes us a long way toward the basic understanding of technology that is lacking in the world today.

A second also cryptic, but somewhat more specific insight, which reinforces Father Ong's more general observation, is one by the author of *The Meaning of Meanings*, I. A. Richards, who has commented that, "A book is a machine to think with."

If the bibliophile resists thinking of a book as a machine and the scholar rejects the thought that the work of ordering and categorizing knowledge is in the same sense a technological act, then I hope that both may at least grant that *those things that are commonly called machines*—such as the lever, the auto-

1/ U.S. Congress. House. Committee on Foreign Affairs. Subcommittee on National Security Policy and Scientific Developments. Foreign Policy Implications of Satellite Communications Hearings, 91st Congress, 2nd session. Held Apr. 23, 28, 30, 1970. Washington, U.S. Govt. Print. Off., 1969. 317 p. Hearings held May 13, 14, 15, and 22, 1969.

mobile, the computer—*may be validly described as human thought and knowledge made tangible* If one does not simply grant, but is also willing to reflect upon the validity of a broader truth hinted at by Richards and more directly suggested by Ong, becomes clearly apparent The first step in this realization is to grasp the idea that, even though when built, a machine is an orderly arrangement of material elements activated by the application of energy, before it could be built the machine had to have taken the form of a well-ordered set of thoughts in the mind of its inventor.

If this is so, then a book with its ordered set of pages, its ordered tables of contents and index, may, indeed, be thought of as a special type of machine, or, in Richards' words, "a machine to think with". And if one can see the truth of Richards' insight, then he may also begin to appreciate the validity of Ong's sweeping observation that in its most basic sense, "Technology has to do with the ordering of the possessions of the mind". Once we grasp and accept the idea that *human thought—rather than physical matter*—is the true *raw material* of technology, we are now in a position to grasp and explore what I have called in the title of this paper, "the radical relatedness of technology and education".

This relatedness is rooted, first and foremost, in the fact that both technology and education are uniquely human activities. (This is not to say other animals are incapable of manipulating their environments or learning to adapt to a changing environment—it is just that the human animal is so much more capable.) *Technology, it would seem, is the sum total of those activities which, in the aggregate, enable man to carry out almost any imaginable manipulation or modification of his external (material) or internal (behavioral) environments* Education is, of necessity, closely related to technology in that it is made up of those activities through which men are able to transmit to one another knowledge of how to manage and adapt to the changes within these environments Of course, education should and *must* do more than this, but to the extent that it is concerned with these tasks of environmental management and adaptation both the content and processes of education must inevitably relate to technology. This is particularly true as man's environment becomes increasingly technological In short, the relationship of technology and education is, today, so close that in many parts of the world educational institutions are in the process of becoming little more than hand maidens of a demanding, world-wide technological master This is readily understandable in a world in which technology keeps creating so much for us to know and our educational systems are so caught up in the task of transmitting this technologically-generated knowledge, that they are failing, among other things, to teach us that technology itself is a human-generated force These educational systems also fail to take into account that while both technology and education are, indeed, human-generated, neither of them, today, are primarily human-centered activities. Rather, they both tend to center on the development of themselves as systems.

To the extent that this tendency grows, we are succeeding in creating a closed technological-educational system. A system which is all too capable of measuring its success in terms of how well it functions not as a means to larger human ends, but in terms of *the system as an end in itself*. Let me give a concrete historical example of what I mean by this general and abstract statement

During the early years of the industrial revolution in Great Britain and the United States, there was a *great* drive to educate large numbers of the population, at least to the basic level of proficiency in the fundamentals of reading, writing and computation, and to provide them while still young with what was then called "moral instruction". In order to facilitate the transmission of the learning contained in their curriculum, special buildings were built capable of containing the large numbers of learners who were to be instructed by a much smaller number of teachers. A system of instruction was developed which could be used by the teachers to instruct the learners in an orderly fashion The system used books in which what was to be learned was, in turn, organized according to the system which the teacher was using. (Or, as was frequently the case, the teacher followed the instructional system implicit in the organization of the book) The avowed purpose of this well-ordered system was, as we have already noted to facilitate learning And at first there was no question that this was indeed its stated and actual objective One very important measure of this is the fact that in the earliest and most famous of the early mass instructional systems (developed by Joseph Lancaster in England in 1801 and in use in North and South America, the European continent and Turkey by 1820) while instruction was conducted in groups. Individual students were able to move from group to group based on their proven mastery of the curriculum.

Gradually in these systems, this primary objective slowly became a secondary consideration. The main consideration became the maintenance and growth of the system itself. An excellent measure of this is the fact that as these systems grew, individual students were less and less frequently allowed to move ahead of their group even though they may have mastered that portion of the curriculum. An even greater measure of this is the fact that students who had not mastered a particular level of the curriculum would be indiscriminately moved ahead with the group to which they had been assigned. It is difficult to find any mass-instructional system developed during the 19th Century which did not lose sight of its original human centered concern for the eradication of ignorance, and which did not make the concern for the continuation and growth of its own existence its primary goal. We have here the classic case of a technological undertaking which was designed with the best of possible human motivations unconsciously transmuted into a mindless ordering of lives by a mindless and eventually unproductive system. One may be tempted to say that this devolution of 19th Century mass instructional systems from their initial human-centered concerns to their eventual self-centered machinistic concerns is simply the nature of any bureaucratic-like organization.

In fact, if I read Jacques Ellul's *The Technological Society* correctly, I believe he is maintaining that this type of devolution is an inevitability whenever men organize their activities on any scale. However, I think it would be too bad to uncritically accept Ellul's unqualified pessimism when it comes to the question of inevitability in technology. Therefore, let us adopt for the moment the posture of qualified optimists and take a critical yet more constructive look at the interaction of technology and education. *I suggest that this look should be taken on as broad a scale as possible—from the beginnings of mass instruction, mass production techniques to the present. If technology has to do with the ordering of the possessions of men's minds, then I maintain that such a sweeping look might suggest to us that for two centuries technology, itself, has, in fact, been a gigantic teaching machine!*

Were we to accept this insight, we might conclude that given the growth of the factory system, with its mass production and assembly line techniques, with its routinized use of human beings, that it taught educators more powerfully than any educational theorist could have—those things needed to be learned by the members of an adolescent industrial society. The fact that 19th Century schooling throughout the industrialized world was a highly routinized, individual constraining experience, is not something that can be considered as having developed independently of the industrial models that were so close at hand.

Whether this is a more likely explanation of the character of 19th Century schooling than the theory that any large scale bureaucracy will inevitably take on these characteristics is difficult to prove. However, it may become a moot point if we look at more recent developments of the interaction of technology and education.

But before we do this, let me restate the case for the "teaching machine" view of 19th Century industrial technology as forcefully as I can. If viewed as a gigantic teaching machine, the lesson taught by the 19th Century industrial technology seems to have been that the human being was not so much valuable in and of himself as he was a component within and a willing consumer of the results of industrial production. As a result, this view of the individual was mindlessly, subtly and effectively programmed into both the formal and informal educational systems of the day. Too often the goal of this technologically dominated educational message became unconscious acceptance of the idea that the manipulation of man's natural resources, via technological means, was a totally desirable and unquestionable social and economic good. In time, the pervasive, persuasive teaching machine of technology began to order the possessions of men's minds so as to accept and expect that they, too, would, and indeed, should be so manipulated. Thus, a major lesson taught by 19th Century industrial technology was that if the individual wanted the benefits of modern industrialism in the form of material well-being, he would unwittingly allow his mind and behavior to be ordered in ways compatable with the technological ordering that had made industrialism work. In short, if the individual wished to benefit materially from modern industrial technology, he had no choice but to gear his life to the mass production mass instruction system on which the 19th Century technology was based.

Today in the second half of the 20th Century, we may observe, particularly in the more industrially advanced countries, increasing numbers of individuals who feel that there are alternatives available to them other than the gearing of their lives to what they consider an outmoded system of production and instruction. Granted that even during the depths of individual-degrading Dickensian type of mid-19th Century industrialism, there were individuals who "opted out" of the system, for individuality always manages to assert itself through the spirit of a few personalities. But the appearance of increasingly larger numbers of such individuals is a unique mid-20th Century phenomenon. The question of why and how this phenomenon has come about is being asked and answered by many different people in many different ways. Let us here attempt to answer it from the "technology-as-teaching-machine" point of view. We have already established that as one looks beyond the essential, mind-ordering characteristic of technology, the less essential attributes which help to define it for us at a particular point in time do, in fact, change over a period of time. This being the case, it is important for us to return to the examination of the changes that have occurred within the defining attributes of technology during this century.

We have previously noted that since the beginning of the century the attribute of behavioral modification or manipulation has been added to and has extended the definition of technology beyond its earlier, more restricted, material-based limits. We have also discovered that this extension is, through a process of implication, destroying the even earlier, even more restrictive definition of technology only in terms of machines. However, I would suggest that from the standpoint of education in general, and in particular from the viewpoint of technology as a world-wide teaching machine, there have been even more important changes among the attributes which define technology in the third quarter of the 20th Century.

The most significant among these new defining attributes was the appearance earlier in this century of what I shall call "optionization" and "immediacy." "Optionization" made its appearance as a new attribute of technology initially among a few industries in the U.S. at the beginning of the second quarter of the 20th Century. The "attribute of immediacy" entered the scene somewhat later. Some of the earliest and most dramatic examples of the emergence of optionization came in the automotive industry in the form of a shift by auto producers and auto buyers away from the production and popularity of cars, like Henry Ford's famous—and highly standardized—Model T automobile, (which as Ford put it The customer could have in any colour "as long as it's black'") toward the production and purchase of automobiles with broader and broader options, ranging from varieties and an array of performance features to the choice of almost any colour imaginable. "Immediacy" was introduced most dramatically through the development and use of media of communications that make information *immediately* available to the individual—*at his option.*

Today during the third quarter of the 20th Century, "optionization" and "immediacy" have become increasingly central to the changing concept of technology. Within the world's more highly industrialized countries both "optionization" and "immediacy" have pervaded almost every area of consumer goods and services. No longer does a single standardized product, whether it be shoes, breakfast cereals, or automobiles satisfy consumer demands. Nor are services such as education or communication considered satisfactory unless there are a significant number of available alternatives, and unless these are available *immediately*. Parallel to this 20th Century shift from *standardization* to *optionization* is the somewhat less obvious but potentially more important shift from an unquestioned willingness to a determined unwillingness on the part of the individuals to gear their lives to the traditional industrial and educational systems. The most important fact about this shift—which in the United States is currently and *most significantly* referred to as "opting out"—is that it is, in fact not a future *hope*, but an *immediate* grasping of an optional life style for large numbers of young people. The second important fact is that this option and the immediacy of its availability exists *solely* because of the highly productive level to which industrial technology has risen during this century.

Without having achieved this level of productivity and the concomitant level of affluence it has generated, no substantial number of people in society could "opt out" and manage to have themselves or society survive. The significance in the slang expression "opting out" is the unconscious recognition that it is the workings of modern technology itself which is teaching that it is realistically possible from an economic standpoint as well as often desirable from a purely human standpoint to "opt out" of the present system.

The giant, mindless, unconsciously programed teaching machine of modern technology has been quietly and unconsciously at work—teaching the young. It has been teaching them that it is possible to step outside the working world of our more advanced technological society and manage to live well enough on the material *effluence* which surrounds the technological mainstream. The Ellulian, or unqualified pessimist's view of this situation might well conclude that what these young people are inevitably opting *for* is a parasitic existence at the expense of the society's more responsible technologically engaged members. And, of course, there is always the chance that this diagnosis is correct.

But let us, for a moment longer, maintain our assumed posture of qualified optimists and look for possible signs of other, more positive outcomes. In fact, let us go one step further in our role-playing and assume the posture of an "opt-out".

You are now the member of that small but growing group who have taken the initiative and taken for *themselves* the prize that the Technocrats and the Marxists have long implied they would win for the common man—the prize of being supported by a man-made, but technologically managed system of production.

But *you* have not waited for the technocratic state to award you this prize. You have grasped it—ahead of schedule, as it were—and are confronted with the question of what you will do, now that you have it. I suggest that there is a chance that you will not begin to live in a parasitic, apathetic way—that there is a chance that for the first time in your life you will begin to realize how much waste is tolerated, accepted, even expected in a technologically permeated world. You find that you have time to think about this—to reflect on it, and even to actively respond to the waste and to the social inequity implicit in that waste. In short, there is a chance that as an "opt-out" you and your fellow "opt-outs" will come to view yourselves as actively performing the function of a social conscience for those members of society who are still so directly involved in maintaining the system that they cannot, or dare not, see its faults.

There is also the chance that in performing this role as an *active* social conscience, you may find yourself reflecting on two facts of your new life:

(1) That it is, in fact, modern technological society that makes your life possible and,

(2) That you are one of the first few who have managed to learn the major lesson being taught by the big teaching machine—that it is possible to maintain a socially relevant, human-centered existence in the midst of a technological society by persuasively demanding that the traditional technological system be adapted to serve the human and material needs of *all* members of society.

If you reflect upon these two facts, and wish to act, you will then be faced with the practical task of forcing the present techno-centered system of education to develop more human-centered techniques. If you don't become actively involved in this social and technological revolution, you and your fellow "opt-outs" may no longer have the option of keeping the prize you have grasped. What then can you as an "opt-out" hope to do that is likely to keep this from happening? What can you do to protect the life which technology made it possible for you to choose, but which a self-aggrandizing technological system threatens to take from you? Let me give you some concrete examples of what is, in fact, being done today in some communities in the U.S. by some small groups of socially involved learners and teachers.

In Milwaukee, Wisconsin, students from both municipal and private schools have "opted out" of this traditional education and formed their own school. They hire their teachers, and are accepted into the best colleges.

In New York City, a school which was formed three years ago to help children who have been rejected by public education is this year, being overwhelmed by applications from students who are performing well in the traditional system but who feel that the system does not provide them with the type of learning options they desire. By a teaching-learning process which uses teachers, innovative teaching materials, and cooperating professionals from the community, students in this school are able to study in a completely individualized program while actually working with practicing professionals. The students in this school are paid for the work they do.

In Philadelphia, Pennsylvania, the traditional school system has developed a similar learning program as an experimental "counter-system" of education. This program, which has been highly successful, amounts to a planned revolution that may radically change existing educational practice and thought.

But let us not miss the point, the significance, and the radical justification of what is going in in these revolutionary situations: The point is that students, themselves, have generated these schools; the significance is that such student action has been prompted by the fact that, *in their opinion*, they were not being serviced by the traditional mass instruction, mass production system; the justification of what is going on here is a conscious shift from the threat of the "dulling standardization" of the existing technologically-controlled system to an emphasis on the stimulating thrust of "optionization" within an evolving technological society. Putting all this in another simpler way: Educators view technology *as it has existed;* students (at least some of them) see technology *as it is coming to exist!*

The question is, then, how can you as an educator bridge this perceptual, conceptual, generation gap?

The first thing that you do is to become fully aware of the radical nature of the relationship between technology and education. By this I mean that you must come to realize at how fundamental a level the human generated forces of technology and education are inextricably intertwined in the contemporary world. Having realized this, you must do what you can to make others aware of this radical relationship and aware, also, of the simple, radical truth that, at their related core, both technology and education have to do with the "ordering of the possessions of the mind". It will then be just a small step for you to see that the real educational/technological issue in the world today is how men's minds shall come to be ordered.

Shall they be ordered in such a way as to become the products of a mass-production, mass-instruction system, or shall they be ordered by an alternative system, the central purpose of which is to make the tools of educational technology readily available to each individual and provide him that most precious gift—the time and security within which to pursue the knowledge he *needs* to function as a human being in a technological world.

The achievement of such an objective, which is nothing less than the redirection and management of present technological/educational systems to this human-centered end, is unlikely to occur given the present mindless pursuit of other system-centered ends that pervade the world today. However, if the educational potential implicit in modern technology can be consciously focused on the task of providing individuals with the means of becoming critically aware of the complex task of maintaining human-centered lives within a technological society, there is hope. If this hope seems somehow odd or incestuous—in that it rests on employing technology to teach ourselves how to deal with technology—we must realize that, in a most profound sense, this hope is the same that each of us asserts as he *faces* the task of using his mind to examine and deal with its own workings and products. My hope, then, is that it is still possible to create human-centered technologically-aided educational systems. And I rest this hope on the chance that educational practitioners, policy-makers, and the general public will begin to realize the profoundly important implications for all humanity residing in what I have termed "the radical relatedness of technology and education".

Were educational systems to be built upon the positive implications of this realization, they would of necessity be systems which centered on developing within the individual an awareness of—and the competence and confidence to deal with—a vast array of learning options from books and other media.

In such a human-centered educational system, students would use technological devices and behaviorally engineered learning materials to acquire a broad range of knowledge. The role of the teacher is no longer that of a human cog processing human products through the machinery of mass-produced instruction. The teacher's role now becomes more human. That is, it becomes the role of helping other human beings achieve the wisdom required to put facts and knowledge to work in maintaining a human-centered way of life.

At the heart of such human-centered system would be the central concern of making the learner aware of the dynamic competition among the teaching and learning systems, the value systems, and the ideologies that have come to characterize the technological world. Furthermore, it would show him the way this competition will unrelentingly affect his own life and the life of the society in which he exists. In other words, it would make him aware of the ways in which technology will affect the ordering of the possessions of his mind! How do we begin to build such educational systems?

The first step is the very practical one of creating "optionized" learning systems which can be used by individual learners with the confidence that what the system is advertized as teaching will, in fact, be taught and can, in fact, be learned by them. This means that all instructional systems, materials, and equipment must be accompanied by evidence that would justify a learner's investment of time and effort in learning from a particular option. Secondly, there needs to be a very clear explication of the values which are implicitly operating with each learning option. Thirdly, there needs to be very open and very free access to this information so that teachers, students, parents and community groups and policy-makers will clearly understand the educational options that are available and how well the various learning materials, vying for the learner's attention, will meet his learning needs.

As I have indicated, attempts to create such systems are currently underway on a very small scale in the United States and other highly industrialized countries. But this does not mean that such attempts need be restricted to technologically sophisticated countries. The opportunity to create human-centered educational systems may in fact be greater in less industrialized countries, where the mass instruction/mass production mentality has not so deeply pervaded the fabric of society. Wherever these attempts are tried, they will meet with the inevitable objections that they are inefficient, in terms of the traditional attributes of a standardized mass-instruction/mass-production educational technology. But in a technological world of increasing optionization, the traditional concept of technological efficiency is—like every other value—now being opened to critical examination and revaluation. I submit that the place to start such critical examination and reevaluation of all the attributes of technology—including familiar attributes such as mechanism, efficiency and standardization as well as newer attributes of optionization and immediacy is within that enterprise to which technology is most radically related. That radically related enterprise is education.

APPENDIX 7

"The Fourth Pevolution: Major Themes and Marginal Observations; Peasonable Goals for Instructional Technology" 1/

The Fourth Revolution

Contents

1/ The Fourth Revolution. Instructional Technology in Higher Education. The Carnegie Commission on Higher Education. New York, McGraw-Hill, 1972. 110 p. (Hereafter cited as The Fourth Revolution)

1. Major Themes and Marginal Observations

1 Higher education (and education generally) now faces the first great technological revolution in five centuries in the potential impact of the new electronics.

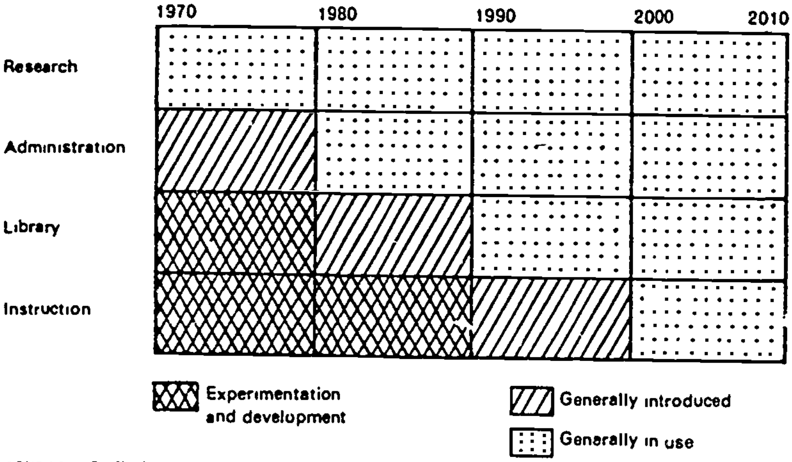
2 New technology has already transformed *(a)* research techniques in many fields and *(b)* administrative methods on many campuses. It is now *(c)* affecting large libraries and *(d)* is entering into the instructional process. Our estimates of the current status and potential utilization of information technology in higher education are shown in Figure 1. The new technology may provide the single greatest opportunity for academic change on and off campus.

3 The experience thus far with the new technology (applied to instruction), however, as compared with the hopes of its early supporters, indicates that it is *(a)* coming along more slowly, *(b)* costing more money, and *(c)* adding to rather than replacing older approaches—as the teacher once added to what the family could offer, as writing then added to oral instruction, as the book later added to the handwritten manuscript.

4 Nevertheless, by the year 2000 it now appears that a significant proportion of instruction in higher education on campus may be carried on through informational technology—perhaps in a range of 10 to 20 percent. It certainly will penetrate much further than this into off-campus instruction at levels beyond the secondary school—in fact it may become dominant there at a level of 80 percent or more.

Better than ever before, it can bring education to the sick, the handicapped, the aged, the prisoners, the members of the armed forces, persons in remote areas, and to many adults who could at-

FIGURE 1 ***Estimated use of electronic technology (computers, "cable" television, videocassettes) in higher education***



SOURCE Staff of the Carnegie Commission on Higher Education.

tend classes on campus but who will find instruction at home more convenient. It can create new uses for leisure time, can facilitate job-to-job movement through new training, and can improve community participation by imparting greater skill and knowledge to citizens. Informational technology is already heavily used in the armed forces and in in-plant training in industry. It is more widely used now in primary and secondary schools than in on-campus higher education and will continue to be used more at those levels in the future. The new technology will also tend to draw instruction from the historical requirements-met-through-teaching approach to a resources-available-for-learning approach; and this can be a fundamental change.

5 For students, the expanding technology has two major advantages: properly applied, it increases the opportunities for independent study, and it provides students with a richer variety of courses and methods of instruction. Students can choose, for example, between a lecture and a computer program, thus introducing competition between the two techniques and potentially raising the quality of instruction in both. Or they can choose total immersion in one subject at a time. They have more options. Much of the new tech-

nology, additionally, is infinitely tolerant and infinitely patient toward the slow learner. It also does not act *in loco parentis* toward anybody. We will note in a forthcoming report *(Reform on Campus)* that two complaints of students are the inadequate variety of courses available to them and the lack of quality in some classroom instruction. The expanding technology can speak to both of these complaints. It can also help supply answers to the two great aspects of "humanization" of higher education (1) by making access easier and (2) by paying more attention to the specific needs of individual students. Students, in order to make good use of the new instructional methods at the college level, must be given new learning skills beginning at least in high school.

For faculty members, the new technology can lessen routine instructional responsibilities in the more elementary work in languages, mathematics, the sciences, accounting, and other fields. It may, however, reduce the need for both teaching assistants and for additional new faculty members at a time when requirements for them are lessening for other reasons. We do not expect, however, that it will lead to the replacement of any present faculty members. It does mean that faculty members of the future will need more training in the new instructional techniques. We believe that the Doctor of Arts degree we have recommended earlier is particularly adapted to the new situation. Faculty members will, of necessity, need to adjust to the new division of labor. Historically they have been all-around journeymen with helpers (TAs), and now they will be working with technicians as well. The academic manning table becomes more complex as it has already become in so many other fields, as for example, in the health professions. Within campus-bound higher education, the techniques of informational technology may well influence instructional methods by making them more carefully thought out even if none of the new technology is used in a particular course. Most or even all instruction will become more analytical in its approach, more conscious about its methods.

For financing authorities, the new informational technology will eventually reduce instructional costs below levels possible using conventional methods alone, but, in the short run, it will only increase costs. It will be financially prudent to concentrate early investments in areas with the greatest capability for wide use: *(a)* libraries, *(b)* adult education, *(c)* primary and secondary education, and *(d)* introductory courses in higher education where basic skills are involved, like mathematics and language.

6 Some implications of the new informational technology are:

- Off-campus instruction of adults may become both the most rapidly expanding and the most rapidly changing segment of postsecondary education.
- Fewer students may study on campus, and more may elect to pursue their studies off campus and get credit by examination. This will reduce enrollments below the levels they otherwise would reach.
- Students in small colleges will have more access to a greater variety of courses and greater library resources. The big campus will have fewer advantages on these scores.
- The library, if it becomes the center for the storage and retrieval of knowledge in whatever form, will become a more dominant feature of the campus. New libraries should be planned with the potential impact of technology in mind.
- New buildings should be built with adequate electronic components. They should also be planned for 24-hour use.
- Some new colleges and universities may be constructed with a central core area and with satellite campuses scattered around within commuting distance. The core area will provide access to knowledge; the satellite campuses will provide a greater sense of community because of their smaller size.
- New configurations will take place to the extent that students are dispersed as consumers and as some faculty members and many technicians are concentrated as producers.
- New professions of multimedia technologists are being born.
- Students will need to be more familiar with the use of certain technologies — particularly the computer — as they begin their college training.
- Prospective high school teachers and prospective college and university teachers will need to be trained in the use of the new technologies for instruction. Many of these prospective teachers who are in college now will still be teaching in the year 2000 when the new technology will be in general use in educational institutions.
- Universities and colleges will be able to trade-off in their overall budget making between funds for construction of buildings for on-campus instruction and operating costs of off-campus instruction.

- Less remedial instruction will be necessary on campus. Students will come to college better prepared or will receive their remedial instruction in off-campus courses or through independent learning assisted by the new technology.
- Good systems for informing and advising students will become more essential and more complex as additional options are made available and as more instructional opportunities are located off campus.
- Many more and better tests will be required to evaluate the progress of students who learn through the new forms of instructional technology.
- Some of the informational technology, thus far, seems better at training skills than at general education. The better it is at training skills, the more general education may suffer as a result—particularly if students move off campus and content themselves with skill training. But instructional technology, represented by such media as television and film, can also contribute to general education and to the teaching of concepts.
- Some equivalent of the university press, or an expanded university press, may eventually be necessary to produce videocassettes and other instructional software that can be used with the new technology.
- Copyright laws will need to be reviewed by Congress to adapt them to the new carriers of information.

7 The new technology will have a centralizing effect:

(a) On campus there will need to be some agency (whether it is the library or some other facility) that will provide equipment and materials, assist in the preparation of programs, and aid in the presentation of programs.

(b) Among campuses, there will be a need for cooperation on a regional or even national basis. We propose the establishment of at least seven regionally organized cooperative learning-technology centers not only for research and development activities, but also for production and distribution of instructional programs designed for use with the expanded media. Such centers will also serve as badly needed information sources for participating members who need to know what instructional materials are available, and which technologies are best applied to specific instructional problems. Participating institutions should be regarded as members of such centers and should have a voice in their policies. Such centers will need to have a full measure of academic freedom and autonomy, for their programs will be more widely influential than many textbooks; and textbooks, on occasion, have become sensitive subjects. Because we lack experience in the operation of such centers, we recommend that they be created, at least initially, on a staggered basis—one every three years until all are completed.

8 There are important roles for governments, industry, and certain nonprofit organizations to play in providing financial support, developing distribution systems, and designing and perfecting instructional software. We believe that no single segment of society should totally dominate the development of instructional materials in higher education and that colleges and universities should take initiative in such activities along with other instrumentalities.

An alternative approach to development of instructional materials on campus and in regional centers and by industry is to set up instructional programs dependent upon the expanded technologies in a separate, competitive national system (as in Japan). A system of this kind might make rapid progress with considerable economy. We prefer, however, that the new instructional technologies be developed in a somewhat more diversified setting in which faculty members also have an opportunity to exercise strong influence. Instruction developed that way will be more readily accepted in the academic community and will be less subject to political intrusion. We prefer a competitive approach with instrumentalities of higher education involved in the competition.

9 The specific new technologies, among the many available, which hold out the greatest prospects in the longer run are:

- Cable TV
- Videocassettes
- Computer-assisted instruction
- Learning kits to be used with audiovisual independent study units

Industry will have the major responsibility for developing and manufacturing the "hardware." Great attention needs to be paid to making instructional components for these media more compatible among the models of several producers than they now are—as has happened previously with record players and TV sets.

10 The federal government will need to provide not only the bulk of the research and development funds, as it has in the past, but also funds for distribution of effective instructional programs that use the expanded technology. We believe that the new technology warrants a minimal expenditure of about $100 million for well-targeted support in 1973, including funds for cooperative learning-technology centers. We recommend that annual federal expenditures for

research, development, and utilization of the new media should increase from the $100 million proposed for 1973 until they reach a sum equal to 1 percent of total national expenditures on higher education. We consider this a wise long-term investment.

11 Higher education should cautiously welcome the new informational technology, not resist it. We see no need for academic Luddites. But, on the other hand, "program or perish" should not replace "publish or perish."

12 Constant evaluation of the results among alternative approaches and of total costs and total consequences will be essential. For example, students learn from each other: Does the new technology reduce this interchange? And faculty members serve as models to their students: To what extent may this contribution be lost? Some independent assessment projects or agencies should be established in the very near future to provide ongoing and impartial study of the total impacts of the new technology.

13 The proposed National Institute of Education can be very helpful with research and development, and the proposed National Foundation for Postsecondary Education can be helpful with innovative programs at the campus level.

14 The United States with its great resources may be able to develop programs and techniques which can extend the advantages of greater learning to less wealthy nations of the world, aiding them to raise their literacy and skill levels faster and at less cost—but any element of political indoctrination must be totally absent. The whole world can be assisted to move faster into becoming a "Learning Society."

10. Reasonable Goals for Instructional Technology

Although the advocates of instructional technology accept the importance of objectives for the learning process, they have been negligent in defining reasonable objectives for the development of technology itself. They have, instead, stressed potentials of the new media and systems, sometimes overstating the case and thus creating fears among those who value the security of the status quo, and fixing disbelief in the minds of those who appreciate the difficulties with which fundamental changes can be accomplished. We prefer a goals approach that concentrates attention on what is both possible and needed.

BY 1980 The Carnegie Commission suggests that the following goals be reached by 1980.

1 *Institutions of higher learning will have accepted a broad definition of instructional technology such as: The enrichment and improvement of the conditions in which human beings learn and teach achieved through the creative and systematic organization of resources, physical arrangements, media, and methods.*

Acceptance of a broad definition of instructional technology is not a matter of semantic convention. It is a tactical step that is necessary to assure that technology will be regarded as subservient to the needs of teaching and learning and not an end in itself. It is also necessary because it conceives of the various media and technologies as working in conjunction with one another, and combines the support and enthusiasm now given to diverse individual technologies into efforts on behalf of the general development of teaching and learning resources. Finally, it embraces technologies whose merits have been established by many years of use, as well as the novel ones that have been only recently introduced.

2 *Most colleges and universities will have devised adequate administrative and academic authority and procedures for the encouragement and appropriate utilization of instructional technology.*

Although many segments of our society have roles to play in the development of instructional technology, educational institutions have the greatest stake in its utilization. Until they exert some leadership in the design and application of learning materials and some demand for effective media, it is unlikely that governments will be able to advance the cause of technology through additional financial support alone or that industry can advance it solely through dedication of production and distribution capabilities for instructional hardware and software. If the development and use of instructional technology on the campuses is made the explicit responsibility of the principal academic officers of institutions, a significant first-step will have been taken.

3 *Colleges and universities who are responsible for training prospective teachers for high schools and colleges will have incorporated instruction in the design of courses and in the effective utilization of instructional technology (as broadly defined in this report) in their curricula.*

The increasing use of technology in instruction will require the availability of teachers who understand the capabilities and limitations of new and expanding media and the procedures involved in effective course design. Preparation of such teachers should not be delayed, because even students who are now preparing to be teachers and professors will be teaching in the year 2000 when we expect instructional technology to be in general use.

4 *A concerted federal government effort, utilizing the resources of the nation's finest libraries and museums as well as the resources of the nation's campuses, will have been made to design and produce courses of instruction of good quality for presentation using advanced electronic media.*

The greatest deficiency in instructional technology at the present time is caused by the inadequate supply of teaching and learning materials of good quality suitable for use with the new technologies. We have recommended that colleges and universities encourage the development of such materials on their own campuses. Beyond the campuses, instructional programs must be developed for utilization by many different institutions in the form of films, video- and audiocassettes, or printed learning modules. Because such forms are least expensive and most effective when widely used, it is especially important they be expertly prepared, drawing upon the best available expertise and learning resources. We therefore believe that resource centers such as the Smithsonian Institution, National Gallery of Art, the Library of Congress, the National Archives, and major metropolitan cultural centers should be used to sponsor and assist in the development of high-quality instructional materials suitable for presentation with various media.

5 *At least three cooperative learning-technology centers, combining the instructional technology capabilities of many member institutions within a geographic region, and originating and directing centralized instructional services through information, communications, and computing networks will be in operation.*

A critical need in instructional technology is for organized effort to create, improve, and utilize effective instructional programs that can take advantage of existing media and know-how. Such efforts require a focus and level of expenditures that cannot be provided by individual institutions.

Through the combined efforts of cooperative learning-technology centers and the institutions described in (4) above, at least 500 instructional units ranging from course-length to quarter-hour segments, all suitable for use with media in their contemporary state of development, could be made nationally available by 1975. As many as 1,500 units could be available by 1980.

6 *The level of federal support for development and application of instructional technologies should have reached a figure equal to 1 percent of the total national expenditure for higher education.*

Individual institutions should contribute as much funding as they possibly can to efforts to advance instructional technology. In view of current financial stringencies faced by many colleges and universities, however, it is now impossible for them to make the full investments that are needed. The federal government must therefore continue to play a major role in supporting instructional technology developments until at least the end of the current century. We have recommended that by 1980 such support should equal 1 percent of the annual national expenditures on higher education.

7 *Extramural higher education programs should be available to most Americans through Open University type programs initiated by existing colleges and universities, states, or cooperative learning-technology centers.*

These new programs will provide for some people an alternative to traditional higher education. But they will also be able to serve—and undoubtedly will attract—many thousands of learners who are not counted in the normal estimates for conventional colleges and universities. These additional thousands of learners can only be served if an adequate instructional technology exists to supplement the services of live faculty members available for such programs, and to accommodate learning that traverses grea distances and schedules of students for whom education is not a primary activity. The very existence of such systems should stimulate the development of instructional technology generally.

8 *Legal restraints upon the duplication of educational materials should have been thoroughly reviewed by Congress with special attention given to their impacts on the capabilities and advantages of instruction provided by the new instructional technology.*

9 *Manufacturers of equipment for uses in teaching and learning at colleges and universities will have made a greater effort to adapt their designs so that compatible instructional components can be produced for use on a wide variety of makes and models.*

The lack of standardization and compatibility in much of the mediaware that can be used for instruction in higher education impairs the full and early development of educational technology. Some standardization will inevitably occur, as it has in other media, under pressures of the marketplace. But we would also encourage government agencies and manufacturers' associations to influence, to the extent they are able, a more rapid accommodation by information and communications industries to instructional needs for a wide variety of materials that are usable on a broad range of available equipment models. The needs are particularly acute in the use of media that utilize computer programs, audiotapes, and videocassettes.

10 *Systems for identifying promising instructional materials will have been developed, and procedures for encouraging their development and utilization will be operable.*

11 *New professions for persons engaged in creating and developing instructional materials on the nation's campuses will have emerged.*

BY 1990 1 *Most colleges in the country will have introduced sufficient technologies of all available and appropriate kinds to realize the following benefits:*

(a) Savings of some of the time professors and senior instructors traditionally spend in personally presenting information that could as easily be presented by other means. A reasonable goal is average savings of at least 15 percent of a professor's time per course.

(b) Provision of alternative modes of instruction for existing courses. There is no longer any reason to insist that students learn everything in the same way. Some students learn some things best from the lecture mode. Others learn certain things best by reading or with maximum use of visual materials. Particularly in fact-intensive courses, or review courses that are prerequisites for advanced instruction, students should have as wide a variety of learning modes available as possible.

(c) Provision of logistical flexibility by allowing students to receive certain amounts of their instruction at times and places that are most convenient to them.

2 *Six of the seven proposed cooperative learning-technology centers recommended in Section 6 will be in operation.*

BY 2000 1 *All instructional technology identifiable in 1972 will be in general use on college and university campuses.*

2 *The availability of education through independent study within and without traditional institutions will have become widespread through applications of the expanding technology.*

The year 2000 could also mark the completion of more than 25 years of concentrated effort toward the advancement of learning through instructional technology. At this point it should be feasible for teachers and students to contemplate the ultimate dream of all those who have given serious thought to the potentials of the new media—a national interconnection of independent information, communication, and instructional resources, with the combined capacity of making available to any student, anywhere in the country, at any time, learning from the total range of accumulated human knowledge.

APPENDIX 8

Description of Satellite Technology Demonstration, Federation of Rocky Mountain States 1/

The Federation of Rocky Mountain States, Inc., headquartered in Denver, was established in 1966 as a partnership of six mountain states—Idaho, Montana, Wyoming, Utah, Colorado, and New Mexico. (Nevada and Arizona, while not members of the Federation, are also participating in the STD.) Its aim is to involve state governments and private sectors, as well as their resources, in a cooperative effort to solve regional problems and to promote and plan for the orderly development of the region. Its councils and committees are involved in numerous studies and activities ranging from transportation to natural resources, from market development to human resources, from arts and humanities to telecommunications. It is a unique regional association involving governmental agencies and private industry, business, and institutions of higher learning.

FEDERATION OF ROCKY MOUNTAIN STATES HISTORY AND SATELLITE PLANS

As early as 1968, the Federation began exploring the possibilities of obtaining a satellite-based education project for the Rocky Mountain States, and in 1969 had submitted a proposal to HEW for a project to improve instruction in small, isolated schools in the region through educational television broadcasting via satellite. At about the same time, HEW started investigating the potential educational uses of NASA satellites. In 1971, NASA accepted an HEW request to make $2.5 million in alterations in its planned Applications Technology Satellite (ATS) to keep the satellite open for use with a possible low-cost ground receiver system, assuming that such a system could be developed. During the same year, NASA, HEW (through its Office of Telecommunications), and the Federal Communications Commission sent through to the World Administrative Radio Conference requesting a 2.5 Gigahertz (2.5 GHz) frequency allocation for direct broadcast via satellite. Such frequencies were available for educational broadcasting and would require relatively inexpensive sending and receiving equipment; higher frequencies are much harder to control, thus necessitating costlier equipment

Shortly after this request, HEW's Office of Education awarded the Federation a contract "to develop and articulate the organizational structure and planning" in preparation for a satellite experiment for the Rocky Mountain Region. A month later the World Administrative Radio Conference in Geneva agreed to accept the U.S. proposal and allocated the 2.5 Gigahertz frequencies. The Federation of Rocky Mountain States stepped up its planning efforts, working out what would be needed to plan and implement a satellite-assisted demonstration for the delivery of social and educational services within the region, such services to be based on the real needs and wants of the potential system users. HEW also stressed that the emphasis of the experiment be placed on the development of the delivery system techonolgy and not broad educational content areas

In January, 1972, a planning grant was awarded to the Federation. That same month the staff of the Satellite Technology Demonstration began meeting with representatives of NASA, the Goddard Space Flight Center, and Fairchild Industries (which was constructing the ATS–F) to begin designing the ground system equipment for all HET experimenters.

THE SATELLITE TECHNOLOGY DEMONSTRATION

The STD mission, which is scheduled through June 30, 1975, has involved an extensive application of science and technology to problem-solving-in-a real world, social environment. It has called for the development of new structures, both public and private, which permit regional, state and local resources to merge in fruitful ways. It has fostered new approaches to the use and coordination of private and public communication mechanisms.

The STD has used the ATS–6 in conjunction with the ATS–3, which has been in orbit and operational since 1967, to explore new modes of audience involvement. Since the ATS satellites offer the capability of two-way audio, the STD implemented this capability by expanding services beyond those available through ordinary one-way television systems. By taking advantage of the ATS–3's built-in audio feedback systems, and by involving the audience in planning and programming, the STD avoided the lack of responsiveness to human needs and lack

---

1/ U.S. Congress. House. Committee on Interstate and Foreign Commerce. Subcommittee on Communications. Telecommunications Facilities and Demonstration Act of 1975. Hearings, 94th Congress, 1st session, held June 4, 1975 on H.R. 4564. Washington, U.S. Govt. Print. Off., 1975. 145 p.

of participation that characterized some previous attempts to apply technology to the solution of human problems. Further, it is a unique telecommunications system in that it is compatible with existing terrestrial distribution systems, but is also capable of reaching beyond their capabilities and coverage areas to the most remote communities of the United States to equalize their educational opportunities.

The STD directly affected hundreds of communities in an eight-state region which includes Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming, in addition to the 61 terminals serving other HET experimenters in Alaska, the Pacific Northwest, and Appalachia. Products and services resulted from cooperative efforts involving broadcast recipients, colleges and universities, state departments of education, and other government agencies, local advisory boards, consultants, and STD personnel. These products and services were primarily focused around a new National public school priority—Career Education. The project was designed to supplement existing educational programs with a careful blending of hardware, software and personnel.

To promote audience use of the demonstration's products and services, a field support network was developed which made the project an integral part of each state and each participating community. Each state has an operating, state-level coordinator of STD efforts working on concert with local part-time coordinators in each of the 56 school sites. The programs these communities receive are produced by the STD at its television studio located in Denver.

The programming of the STD is categorized as follows:

"Time Out"—a 35-minute program broadcast Monday through Friday which utilizes pretaped segments of dramatization to present career education information to junior high students. In addition, live segments of this program allow the students at the 24 sites with two-way voice capability to ask questions of the STD staff educators and receive immediate responses via the satellite.

"Careers and the Classroom: A New Perspective for Teachers." A one-hour live program broadcast every other week providing career education in-service training for teachers, including a two-way voice segment.

"Footprints" A one-hour evening "special" broadcast every third week which is a series of topical programs designed for the total community, including two-way voice.

"Materials Distribution Service." A central library of 426 educational films covering subjects for grade levels K-12, which can be requested by the 56 sites and are broadcast via the satellite for videotaping by the schools for play-back at a later time.

"Emergency Medical Training Refresher Course." This is a joint project of the Federation of Rocky Mountain States, the Mountain States Health Corporation and the Rocky Mountain Corporation for Public Broadcasting to develop a series of 8 programs to serve as a refresher course for certificated emergency medical technicians. The STD, working through its field structure, arranged for the use of local site facilities and equipment to implement this program.

The STD is a "user-based" system in that the programs are the result of a needs assessment which was conducted in the region and which allowed the users to define their educational needs. Once the broadcasts began, weekly evaluation reports from both teachers and students provided an ongoing critique of each program and suggested improvements which form the basis of modification of future programs. This close rapport with the "field" is maintained by a field service staff which includes a state coordinator in each of the eight states. The field structure is completed with site coordinators in each site who implement the STD in their community by localizing the STD programs to meet the needs of their unique populations.

The STD, if continued, could lead to a series of experiments in using a wide variety of communication systems to deliver diverse and expanded social services to areas which presently have limited resource and limited communications capabilities. Since the STD is a demonstration, its present goals are directed toward gaining information about feasibility, effectiveness, and cost that can guide future efforts. Naturally, the ultimate goal for this and future efforts will be to produce substantial, long-term, educational, and human benefits.

The STD has brought a vast, rugged land closer together. Because of its geography, demography, ethnology, economy, and educational systems, the Rocky Mountain Region was selected as one of the places where the knowledge of space telecommunication accumulated during the past two decades would be brought to earth to support the activities of human beings.

The Federation's experience as one of the six Health-Education Telecommunications experiments shows that there is a time delay between the development of any new communications technology and its acceptance and application for public benefit.

This lack of understanding, sometimes almost a fear, of new technology when coupled with the normal resistance to change is often costly. The time lag between our technological capability and the willingness to accept and utilize what scientists and engineers have made possible is a matter that concerns agencies and organizations engaged in delivery and dissemination of health, education and related social services.

The Satellite Technology Demonstration, during its operational period from September 9, 1974, to May 16, 1975, illustrated clearly that user acceptance of new technology can be established, maintained and verified.

APPENDIX 9

Description of Spartansburg, S. C. Two-way Cable Television Project 1/

The Spartanburg two-way cable project consists of a series of experiments to determine the benefits of interactive cable for the delivery of public services. The work is supported by the Research Applied to National Needs (RANN) program of the National Science Foundation. Like the other projects funded in the NSF cable research program, the Spartanburg project is intended to provide data on the costs and benefits of cable television systems that can be used both to receive and to send signals from a home, agency, or business.

The primary research goal is to test the educational value of alternative forms of return communications on a cable system. In addition, thee project has 3 developmental goals: to test two-way technology in an ongoing service program, to design and test systems of terminals, software, and social procedures for the use of a two-way system, and to test the market for specific services. Two of the programs we have offered illustrate several results directly relevant to a rural demonstration. The first uses home data terminals for adult education; the second uses cameras and return video transmission for the training of day care personnel. The opinions expressed here are my own, and do not necessarily reflect the views of The Rand Corporation or its sponsor in this work, the National Science Foundation. Let me begin with some background about Spartanburg, its cable system and its public agencies.

SPARTANBURG AND ITS CABLE SYSTEM

Spartanburg, South Carolina, is a city of some 45,000 residents. It lies just off Interstate 85 in the northwest or Piedmont area of the state. The cable plant there is one of 15 systems owned by TeleCable Corporation of Norfolk, Virginia.

TeleCable has had considerable experience with two-way systems. Its Overland Park, Kansas, plant was the site of several two-way experiments, and TeleCable's efforts to provide a means there for educating severely handicapped teenagers received some attention in the trade press in the early 1970s. That experience was incorporated in the design of the Spartanburg system, which is in one sense a second generation two-way cable plant.

The Spartanburg cable plant now passes in front of 14,000 dwellings, and 7,000 subscribe to cable service. The cable plant was designed to have a full, high performance, two-way capacity. The basic design was for a hubbed, single-cable plant with 27 forward or "downstream" and 4 return video channels. A variety of design specifications for amplifiers, trunk cable, connectors, and subscriber drops sought to permit the simultaneous transmission of forward and return signals and to minimize the ingress of foreign signals. The quality of the system was assured in construction by local supervision and by strong factory support from Jerrold Corporation. Jerrold had a turnkey contract to construct the system, and used Spartanburg as a testbed for the development of its line of two-way equipment. Though construction was occasionally slowed for factory changes in amplifier modules and other hardware, the net result was a system that was expected to be free of many of the problems that have plagued other two-way cable systems. Thus a central reason that Spartanburg was selected as a site was because it provided a good test of what could be accomplished with the cable technology of the early 1970s.

DATA RETURN AND ADULT EDUCATION

In choosing what services should be offered, the project began by systematically canvassing the community for service needs. High school education quickly emerged as a priority area. The need for adult education is particularly great in South Carolina, where 32 percent of adults do not have a high school education. Some adults do try to go back to school, but their success is limited by many barriers. In 1973–74, less than a third of the 888 students enrolled in Spartanburg County completed the course they started. Of those who gave reasons for dropping out that were not job related, over a third cited barriers that might be overcome by educational television in the home. Most of these said they could not continue to arrange transportation to class; others cited child care, health, and other family problems tying them to their home.

Adult education also seemed a good choice because experienced teachers in this field felt that interaction was essential to student progress in the classroom. The need for interaction and some way of reinforcing the student becomes even more important when the student is in his home, isolated from informal contacts with other students. A two-way capacity cable system seemed to offer the means of providing student participation in ways that ordinary instructional television could not.

1/ U.S. Congress. Senate. Committee on Commerce, Science, and Transportation. Subcommittee on Communications. Rural Telecommunications. Hearings, 95th Congress, 1st session, held Apr. 6, 1977 on Oversight of Rural Telecommunications. Washington, U.S. Govt. Print. Off., 1977 138 p.

In Spartanburg, home terminals have been provided to students enrolled in the high school equivalency program at Spartanburg Technical College. Teachers offer instruction from a TeleCable studio and present questions in a multiple choice format. The terminals transmit data signals that show the teacher which students are answering and whether they know the correct answer. In a second mode, the students are able to indicate they would like the teacher to review the last point, move on to new material, or other messages

Spartanburg Tec has now offered home-based adult education using this system for a year and a half. Three classes of high school level instruction have each run 12 hours a week for 15 weeks to prepare students to take the high school equivalency examination Each class was structured to test two-way cable instruction with education in the conventional classroom. On a typical day, the math teacher would instruct her class over cable from 8:30 to 10:00 a.m. and then drive to Spartanburg Tec where she taught the same lesson to a regular class from 10:30 a.m until noon. The reading teacher would have the reverse schedule, instructing the conventional class at Tec until 10:00 a.m., and starting the same reading lesson over cable at 10:30 a.m. Thus the two groups of students received the same instruction from the same teachers on the same days. The results were that the students using the two-way cable system learned just as much as students taking the course in the regular classroom This very simple system of an 8-button terminal to respond to live instruction is a viable educational concept.

MULTIPOINT VIDEO AND DAY CARE TRAINING

When discussing service delivery problems with agencies, we found that suggestions for applications that involved return video were most common Although these potential uses tended to be fairly disparate, one pattern emerged: Return video, allowing viewers to interact by showing skills and sharing experiences, was considered a valuable way to strengthen group activity. Several possible applications emerged that could enhance communications among existing professional units; perhaps the most interesting possibility was to use return video to enhance training by building upon occupational or other functional group identities One such example, and the second application chosen for the Spartanburg project, is the use of return video to train day care operators

The need for quality day care has grown substantially in recent years as the number of women in the work force has grown Child care in centers has grown more sophisticated as more positions are filled by well-trained personnel, but in-home and family care is a continuing problem In these situations, the child either remains at home or is kept in the home of the caregiver, typically a neighbor or relative who is often a mother with children of her own. All too often this caregiver sees herself as little more than a babysitter. Even if she would like training, it is difficult to acquire because she is tied to her home In the day, she must usually care for several children by herself, in the evenings and on weekends she must tend her own family Of course, some caregivers are so motivated they attend occasional training workshops despite the inconvenience, but for the general population of this type of caregiver, effective training needs to reach into the home

Two-way cable has been configured so that training for a caregiver can be shared over television The workshop format, already a common training format in this field, lends itself to this approach Rand staff and other visiting professionals from the Spartanburg area have run programs originating both in the studio and in day care centers Viewers of the training program view workshops conducted in the homes of participants and know that they will be asked in turn to serve as the workshop site. Cameras are located in other centers so that the professional on any one day can ask questions of other members of the group, and ask them to demonstrate skills, concepts, and creative ideas A set of individuals that might not ever meet are brought together as members of a telecommunications group, seeing and being seen, to share experiences and to gain expertise

To isolate and measure the value of return video the day care centers in the cable area were randomly divided into two groups Caregivers at the first group of centers received and used cameras and could only watch Tests at the end of the program revealed those without cameras learned just as much as those who actively participated and could be seen over the cable Thus return video did not seem to be having a return video capacity and did not add to each individual student's learning The data did show, however, that the viewer enjoyed the live interaction, and it strengthened their involvement in the programs The lesson seems to be that the greatest value of two way video is a means of developing low-cost programs that can be generated in the local community

CONCLUSION

There are a variety of policy implications that can be derived from our own findings, but let me emphasize 3 points that bear directly on the future of rural telecommunications systems. In general, they are derived from the difficulties we had starting the Spartanburg project.

First, technology is *not* the major issue. Cable is only one of several technologies available to provide telecommunications services, and the best and cheapest system is likely to use a mix of technologies. Too often we have chosen a technology, and raced out to find uses for it. A more logical way of proceeding is to make decisions about what we want to accomplish, and then choose the appropriate technology mix to accomplish that task.

The difficulty, and my second point, is that we do not know what telecommunications services rural areas really want. In Spartanburg, we began by assuming that the greatest need—and therefore the greatest market—for educational services was for adults without a high school diploma. The same assumption was made about rural areas in a staff paper prepared for OTA's rural telecommunications conference. That need may be the greatest, but there is some doubt that students will enroll in high school programs in vast numbers. On the other hand, parents have turned out in remarkable numbers for our parent education programs on child development, a response we had not anticipated. Thus, before a major demonstration is launched, careful needs analysis must be coupled with a thorough ascertainment of what rural citizens and local agencies want and will participate in, as opposed to what federal officials or technologists feel that they should have.

Third, even if we were sure what services we wanted to offer and local services agencies in a rural area were eager to deliver those services, there would still be many barriers to telecommunications services.

Each service area has an array of rules and regulations that seek to safeguard the rights of the clients and to ensure funds are not shifted to serve some other client group. Bound by these rules, it is very difficult to combine services and funding; without such combination, one cannot achieve the economies of scale essential to a cost effective telecommunications system of service delivery. Without enabling legislation permitting waivers of categorical program requirements and strong federal agency support in revising eligibility reuqirements, reimbursement procedures, and professional standards, any rural demonstration will be crippled before it begins.

APPENDIX 10

Description of New York City District 18 Instructional Support System Program 1/

BOARD OF EDUCATION OF THE CITY OF NEW YORK
Office of the Community Superintendent
COMMUNITY SCHOOL DISTRICT 18
[illegible]
Brooklyn, New York 11236
[illegible]

[illegible]
Community Superintendent

[illegible]
Deputy Superintendent
[illegible]
[illegible]
[illegible]
[illegible]

The act which amended Subdivision 11, Section 3602, of New York State's Education Law in 1973 contained a provision that charged the Education Department with '...the development and implementation of a comprehensive student evaluation program for elementary and secondary education.' In considering how best to respond to this legislative charge, the State Education Department (SED) concluded that the legislature's intent as well as the needs of New York State's educational system would be served best by developing a capability for comprehensive student evaluation within the broader framework of a Comprehensive Instructional Management System (CIMS) designed to improve the impact of elementary and secondary educational programs.

The above act was a way of responding to two decades of repeated attempts to bring about large-scale, stable improvements in instructional effectiveness in urban school districts, particularly in basic skill areas. These attempts have featured, either singly or in combination, the infusion of additional (frequently massive) resources, interventions by teams of specialists, and the introduction of modern, technological tools and "scientific" management techniques. With the exception of the ISS experiments in the Guilderland (N.Y.) Central Schools and in District 18, none of these attempts, has been successful in achieving this goal. At this time, the problem of improving instructional effectiveness in urban school districts is considered in many quarters to be intractable, and national and regional resources are being redirected to address problem areas where, it is believed, positive results can be obtained more easily.

In 1973, the State Education Department chose to pursue the design of CIMS through the further development and gradual implementation throughout New York State of an Instructional Support Subsystem (ISS) that had been devised by a group of consultants from Riverside Research Institute, who are presently called Metis Associates. ISS is a component subsystem of CIMS. Implementation of ISS began in New York City's Community School District 18 in 1973. During the 1974-1975 school year, District 18 had an ISS-based mathematics program "up and running" in grades one through six in all the district's 13 elementary schools. At the present time the mathematics program is being implemented in all grades, one through nine, in all the district's elementary and junior high schools.

The implementation of the ISS program could not have occurred if funding were not available. New York State provided research and development money starting in the early 1970's to Riverside Research Institute to initiate a systematic approach to curriculum in the Guilderland School System in New York State. This was then followed by the development of a more sophisticated support system in District 18, Brooklyn.

District 18 obtained the following grants:

Year	Grant	Amount	Result
1974-75	Title 5	$90,000.00	Enabled the District to design the mathematics curriculum during workshop sessions
1974-75	ESAA	428,000.00	Enabled the District to implement the project in each elementary school.
1975-76	ESAA	600,000.00	Enabled the District to revise the elementary mathematics curriculum and add the 7th grade to the system. The reading curriculum was begun.
1976-77	No grant		
1977-78	NY State grant	300,000.00	Enables the District to implement the ISS in all elementary and junior high schools from grades one to nine.

1/ U.S. Congress. House. Committee on Science and Technology. Subcommittee on Domestic and International Scientific Planning, Analysis and Cooperation. Computers and the Learning Society. Washington, U.S. Govt. Print. Off., 1978. 48 p. (Hereafter cited as Computers and the Learning Society. Committee Print).

As the educational leader of District 18, Brooklyn, I am confronted with the most challenging responsibility of making the instructional program more responsive to pupil, school, and district needs Today this challenge becomes even greater with shrinking funds and resources Thus one must conclude that the approach lies in coordinating and allocating limited resources for specific programs.

The primary goal of the Instructional Support System is to enable teachers to individualize instruction based upon pupil needs. ISS provides additional discrete information related directly to the curriculum With the ISS components in place, the district has a system that

Brings about a uniform teacher generated curriculum in all the schools of the district

Brings uniformity to program elements (objectives, activities, test items) and performance criteria used in the classroom

Gives teachers more time to spend on the delivery of instruction to students by providing computer support for scoring tests and keeping records

Improves the overall efficiency and effectiveness of instruction and management within the classroom, school, and district.

Improves reporting to all groups in the district that are involved with education School Board, supervisors, parents, teachers, and students

Develop a clearer understanding of role definition, responsibility, and function

Description of Program

The system was designed primarily to assist teachers in organizing instruction and measuring results in terms of student mastery of specific instructional objectives ISS will serve as a direct support to the teachers for a given curriculum area (i e , reading, mathematics, social studies, etc) It will furnish the teacher with a package that includes instructional objectives for each grade level, activities to meet the objectives, suggested materials, and mastery tests to be administered periodically

Components of ISS

The ISS project has several components They are

The development of the instructional objectives, activities, materials, and test items Lists of instructional objectives were developed by a teachers' workshop program They examined the existing New York curriculum, broke it down into small units called modules, adapted instructional objectives from existing sources, and wrote new ones when necessary The group also developed the activities, materials, and test items that can be used to reach the objectives and assess student mastery In this way, some of the most effective teaching practices were recorded and documented. The package produced by this team was realistic and relevant to the curriculum and the school conditions

Staff Training

The training program for teachers and supervisors in the use of the ISS material will be an on-going activity In addition to the initial orientation and training period, workshops, training sessions, and small group meetings will be held throughout the school year On-site assistance will also be available to staff members as needed. Staff members will constantly have the opportunity to discuss their experiences with other staff members and resource personnel and offer feedback on any aspect of the program

Implementation

The implementation component has two aspects The first of these is the teacher's use of the program in the classroom, along with the on-going teacher training program The teacher receives the ISS material broken down by grade level and curriculum area, and plans her lessons using the lists of instructional objectives, activities, and materials she feels are appropriate When a unit or module is completed by a student, a test is administered and scored by computer The results of the test tells the teacher whether or not the student has mastered the objective being tested Comparing test results with her own observation of classroom performance, the teacher can use the information diagnostically to focus instruction on pupil strengths and weaknesses

ISS, therefore, provides a valuable approach for the teacher--it helps her organize her work, find each student's level, individualize instruction by suggesting remedial, enrichment, or initial teaching materials and activities, and provides immediate feedback through the computer scored tests.

The second aspect of the implementation process is assisting principals and assistant principals in using ISS to better manage their resources. By examining the data, school supervisors and administrators can begin to make decisions about reallocating resources and thus close the feedback loop. For example, by using ISS to pinpoint needs, they can make changes in the activities to which paraprofessionals are assigned, order different types of materials, request special personnel, such as, a remedial reading teacher for specific help, develop projects for the use of reimbursable funds and, in general, use the ISS information to support their objectives and priorities and document their budget requests.

Since the ultimate purpose of any educational system is to improve the achievement of its pupils, the ISS coordinates the many and varied facets of the pupils instructional environment so that there is a most propitious interface between the child and the total education system. To achieve this end there must be a rapid feedback of data to the professional staff which would enable them to evaluate their performance and further enable them to organize their learning environments for efficient and effective delivery of instruction.

The educational components come together in a feedback system that can improve student performance by,

Detecting differences between expected and measured achievement by each student on program objectives.

Taking immediate corrective action with respect to instructional resources being used and instructional activities being implemented in the classroom.

Taking long term corrective action with respect to the instructional resources and activities made available to classroom teachers.

In a report to the Governor of New York by the Department of Education entitled "Evaluation, Elementary and Secondary Education," the Department's review of existing methodologies found them to be inadequate in determining the extent to which pupils are successfully mastering basic skills.

It was found that

Grade norms from standardized tests are being misinterpreted. It is not generally understood that 50% of all pupils in norming process will fall below grade-level.

Test items do not show pupil performance in relation to a defined set of skills that constitute points on the continuum of learning.

The test does not measure ongoing pupil progress within the school year. Therefore, meaningful adjustments in educational programs cannot occur because of the lack of information.

There is a misinterpretation of grade scores. Thus a third grade pupil scoring 7.5 grade level does not mean he reads as well as a seventh grader.

One can therefore conclude that if an educational program is to be effective, it must contain an ongoing means of evaluation that has meaning to the professional staff, parents, and pupils.

In ISS, criterion reference testing has been found to be effective in delivering the necessary information to the professional staff. The criterion reference tests measure whether or not students and/or programs have been successful in achieving behavioral objectives. Undoubtedly, the criterion-reference approach is a more effective procedure for assessing the effectiveness of instructional programs by the professional staff. The results of this testing procedure will be beneficial to the district office, school staff, and pupils.

The benefits of the results to the District Office are as follows.

It supplies the District Office with objective data on the progress of a program.

It is an evaluative tool that determines the degree of success of a progr m.

It will enable the District Office to allocate resource based on data.

It will enable the District Office to report to and advise the Local School Board on short and long range matters of program, policy, and objectives.

It will enable the resource staff to determine learning experiences which are inappropriate for the pupils.

It results in uniformity of program elements (objectives, activities, test items).

The benefits of these results to the school staff are as follows

It supplies the necessary data to enable the principal to effectively plan and schedule programs, order and allocate materials and supplies, reassign teacher talent and resources on an ongoing basis

It enables the supervisors to classify groups of pupils for specific and selected teaching strategies

It enables the principal to adjust the instructional patterns so that they relate to the specific objectives of the school and district.

It enables the principal to measure school-wide curriculum growth.

It gives the principal accurate information that could be used to inform parents at association meetings.

The teachers will not only be able to determine the degree of pupil mastery in their classes but will also be able to pinpoint tasks that were not mastered

The teachers will have information at frequent intervals that will enable them to focus on learning strategies necessary for mastery.

The teachers will be able to better manage their classroom resources to individualize their instruction to the greatest possible degree.

The teachers will be better able to assess and inform parents about individual pupil progress

It will alert the teachers to the pupil's status in a content sequence and enable them to start from "where the pupil is."

It will help the teachers pinpoint remedial work needed by pupils.

It alerts the teachers to the longitudinal curriculum content and enables them to recommend proper future class or group placement.

The feedback instruction enables the staff to modify, adjust and improve the curriculum

The ISS scoring of tests also gives teachers more time to spend on the delivery of instruction and less time on clerical details

The benefits of these results to the pupil are as follows

It reduces tension associated with tests because students performance is not measured in terms of passing or failing but rather in degree of mastery

It motivates the pupil toward greater achievement.

It reduces pupil frustration because instruction is individualized and begins where the pupil is at rather than by a prior teacher judgment

Negative discipline within a classroom is reduced to a minimum because the pupils encounter success with a work level which is determined by the test results.

The criterion reference tests measured mastery of specific instructional objectives Predetermined performance criteria were used to assess student mastery

In summary, the information received with the Instructional Support System enables the total professional staff to plan an efficient delivery of instruction resulting in maximum pupil achievement.

District 18 has been so impressed with the results of the ISS in mathematics that it has utilized the very same successful processes in the development of other curriculum areas, such as, bilingual education, career education, metric education, basic writing, reading, etc There has been a major thrust in District 18 in developing a skills reading program for the early grades via the ISS. Although it is still in its infancy, the curriculum areas (phonics, structural analysis, and readiness) that have been designed have been requested by teachers not only in the pilot schools where the curriculum was tested, but also by teachers throughout the entire district. Unfortunately, these areas do not enjoy the benefits of immediate feedback by computer.

APPENDIX 11

Description of the PLATO System 1/

HISTORY AND PRESENT STATUS

The PLATO program has been in continuous operation at the University of Illinois since 1959. From its inception, this program has been committed to the objective of bringing the power of the modern computer directly into the hands of the general public for the purposes of instruction and education, where the term "education" has been used in the broadest sense. During the period 1959 through 1967, the PLATO I, II, and III systems were developed and tested. These efforts clearly established the validity of the basic concept of computer-based education and the importance of moving from the demonstration phase to the development of a practical, widely deployable system.

Over the past ten years (under a combination of State of Illinois, industrial, private, and Federal support) this practical system, PLATO IV, has been designed and implemented. The specific goals of the program during this period have been to accomplish the system and development, to implement a system of at least 500 terminals, and to evaluate the effectiveness of the utilization of the system in a variety of institutional settings and in a variety of modes of service.

This program has resulted in an operating system of the following general characteristics:

1. Approximately 1000 terminals are connected to and operate from one central computer system.
2. Each individual terminal provides to each of the users an interactive graphics capability with essentially instantaneous response to each input by the user, independently of the fact that hundreds of other users may be simultaneously using the system.
3. These terminals are geographically distributed across the entire nation with locations in more than half of the states.
4. The terminals are installed in elementary schools, community colleges, universities federal agencies, industrial organizations, primary schools, and homes.
5. The system presently delivers approximately one and one-half million contract hours of service per year.
6. Over 6000 hours of instructional materials are presently in use. These materials range in content from pre-school reading to graduate quantum mechanics and in pedagogical style from drill-and practice to complex simulations and interactive tutorials teaching sophisticated concepts.
7. The system is used for instruction, educational and social science research, research computation, data processing, on-line research (ranging from chemistry to biophysics), information distribution, communications, entertainment and recreation, counseling, records maintenance and compilation, information retrieval, and in a wide variety of other uses.
8. A national community of thousands of teachers, researchers, authors, and scholars and tens of thousands of students interact through the system and cooperate on a daily basis to explore new ideas and uses of the system.

The implementation of this system involved a major program with a wide variety of components, including:

1. The development of a sophisticated computer system architecture to support a large number of geographically distributed terminals using ordinary telephone lines for communications.
2. The development of a fundamentally new software system, which provides the naive user with graphics and calculational capabilities equivalent to sophisticated research languages as well as judging, branching, and other instructional options available on other CAI systems. In addition, the system provides management facilities to support the organization and operation of thousands of classes.
3. The development of a series of sophisticated graphics terminals and a series of peripheral devices designed to meet the needs of the user, rather than have the user adapt to the capabilities of "off-the-shelf" equipment.
4. The development of a new computer display technology, which has subsequently been applied to a wide variety of other computer applications.
5. The transfer of this technology to industry in order to establish a source of supply for the needs of this as well as other programs.
6. The enlistment of a variety of educational institutions to participate in the testing of the system and the development of a complete range of support functions necessary for the users of a completely new medium.
7. In addition to this system development and the deployment of hundreds of terminals, thousands of hours of new course materials were developed and tested.

This program was conducted over a four and one half year period in conjunction with the evaluation efforts summarized in the following section.

IMPACT TO DATE

We have clearly demonstrated that such a system can be deployed and operated, while maintaining the high level of performance indicated above. In addition, we

1/ U.S. Congress. House. Committee on Science and Technology. Subcommittee on Domestic and International Scientific Planning, Analysis and Cooperation. Computers and the Learning Society. Washington, U.S Govt. Print. Off., 1978. 48 p.

0 - 81 - 19

have shown that the technology can be effectively transferred, in that there are now industrial suppliers for all of the hardware and software components of the system. There are also three other PLATO systems in operation, with more being planned.

We have shown that the system is widely and enthusiastically accepted. Attitudinal surveys continually show almost unanimously high enthusiasm not only on the part of teachers and students but also by researchers, administrators, and other users of the system. As reported in an independent study by the Educational Testing Service, this high level of acceptance is due in large part to the intentional involvement of classroom teachers and administrators in the development of the system. This is in contrast to many educational experiments, in which solutions have often been imposed from above.

Evaluation of educational programs is an extremely complex problem. When easily-defined performance characteristics are the objective of the program, relatively straightforward and meaningful evaluation results can be obtained. However, when complex educational objectives are involved, meaningful evaluation is extremely difficult. Further, when one is faced with the problem of integrating a new delivery system with standard classroom instruction, evaluation efforts are confounded by the need to attempt to isolate the relationships between causes and effects. Also, materials developed during the early part of this implementation were produced by classroom teachers rather than by professional curriculum developers, to insure user acceptance. Nevertheless, the following general observations concerning the educational impact of the system can be made.

First, we have been able to demonstrate that, in some cases, the augmentation of standard classroom instruction with a small amount of instruction on the PLATO system can produce major overall gains. For example, in the case of elementary math, the average growth over a normal school year for 4th, 5th, and 6th grade children (receiving approximately 25 minutes of PLATO instruction per day) was over 200% of that for children in control classes.

Second, out of many studies, we have documented one case, elementary reading, where the use of the system seemed to produce a small negative impact on student performance, as measured by standardized exams.

Third, we have found in many cases that no significant difference has been shown in student performance on standard test instruments.

It is important to remember, however, that performance on standardized tests is only one measure of educational effectiveness. In many of these cases, teachers report that they clearly see other indications of improved mastery of materials by the students, students themselves express the belief that they have understood and learned more, and students indicate (both by responses to questionnaires and by improved class attendance) that their attitudes towards specific courses and education in general were made more positive by their experience with the system.

In the final analysis, perhaps one of the most significant measures of educational effectiveness is the desire shown by teachers and students to continue and expand their use of the system. If this is the case, the educational effectiveness of the present system is very high.

Finally, we have definitely begun to see, during the past year, that users are developing greater understanding and skill in developing new materials and in managing the use of these materials. The result is that even the narrow measures are beginning to show significant positive results, where previously there were "no significant differences." The system promises to be an extremely powerful tool for educational research, potentially providing breakthroughs in understanding of the learning process as well as providing means for translating this understanding into effective teaching programs.

In summary, the system works, it is enthusiastically received, and there is strong evidence that it can have broad positive impact on teaching effectiveness. Further, in addition to the many instructional uses, it has been effectively utilized in a broad spectrum of non-instructional modes, with great success and with promise of even greater success and breadth of application in the future.

IMPLICATIONS FOR THE FUTURE

In the demonstration of the system which is to be given to the Committee, we shall attempt to emphasize that we are confronted with a technology which is much broader than an instructional system. You will see examples of a variety of on-line uses of the system, including:

1. Instruction
2. On-line communication to other users.
3. Electronic mail
4. Interactive computing.
5. Information retrieval and distribution.
6. Data processing.
7. Recreation and entertainment.

In addition to these services, we are beginning to explore the use of the system in:

1. Medical services.
2. Career counseling.
3. Psychological counseling.
4. Financial planning and counseling.

5. Public forums.
6. News distribution.

Not only are these services available to the users of the system at the University of Illinois, but we are beginning to interconnect with other PLATO systems. In particular, we believe that PLATO is part of the emergence of a new technology, the computer-based communication/information network. We further believe that this new technology has extremely broad implications for the nation. It is entirely feasible to implement a nationwide network, over the next two to three decades, which could link every household and institution in the nation. This network could provide all of the services listed above, and many others.

The fundamental technology for such a network exists. Many major developments which will expand and enhance the value of such a will take place over the next several years. In addition, a great deal of effort in systems engineering, in development of service packages, and in development of utilization techniques and management skills remains to be done. However, no major technological breakthroughs are required to implement a network of major social, economic, and cultural impact. This impact on the productivity of the nation and on the quality of life of our citizenry could be immense.

With the existence of such a network, any individual could instantly receive "mail" from any part of the country. All individuals could have an automated-search access to the national library. The elderly and the physically disabled could have access to an endless array of interactive enrichment activities with participants throughout the country. Any individual could receive instruction in courses offered by educational institutions across the country.

Job retraining and job relocation could be greatly facilitated and could minimize the loss of income to the individual worker. Special attention to the learning-disabled and the handicapped could be obtained on a broad scale. Communities of individuals, without regard to geographical boundaries, could interactively function in problem-solving, social, and cultural pursuits on a scale and in a fashion not previously possible.

One can go on and on about the value of such a system to the nation, in terms of productivity, quality of life, and international trade. However, this listing of specific examples fails to give an accurate perspective of the potential importance of this new technology.

In particular, our capability to solve the great problems which affect the survival of man as a species (energy production and control, population, ecology, poverty, war, etc.) is and will be directly determined by our ability to accumulate, organize, and distribute information and knowledge. In fact, a good working definition of man is that he is that species which attempts to gain adaptability (the requisite of survival) through the gathering of information (data), the organization of that data into knowledge, and the application of that knowledge. It seems eminently clear that the highest priority for man's research should be given to those activities which give promise of improving this most fundamental of all human efforts.

APPENDIX 12

DESCRIPTION OF THE TICCIT PROJECT 1/

Brief History of the TICCIT Project

Early in 1971, the National Science Foundation funded two organizations, the MITRE Corporation of McLean, Virginia, and the University of Texas CAI Laboratory, with two separate but related contracts for investigations leading to the further development of MITRE's TICCIT computer system concept. TICCIT stands for Time-Shared, Interactive, Computer-Controlled Information Television. The concept of using mini-computers, television and cable distribution to produce a low-cost CAI system had been developed extensively by MITRE on the strength of a substantial internal commitment prior to this time.

MITRE was to design and develop hardware and software, and Texas to develop courseware in freshman mathematics and English, the entire system targeted to meet instructional needs in junior colleges. A needs survey conducted under the University of Texas contract resulted in the finding that the major needs of junior colleges lay in so-called remedial mathematics and English [illegible] ial additional courseware development was required, and it was proposed that additional courseware teams be established at Brigham Young University's Instructional Research and Development Department under the direction of M. David Merrill. NSF subsequently funded MITRE for follow-up work with Texas and BYU as subcontractors for courseware systems design and development, co-ordinated by the Texas Lab.

The story of the origin of TICCIT, with its unique learner-controlled courseware and the "factory" to produce it is a story of cross-fertilization between these three organizations Unlike manufacturers of computing equipment, the not-for-profit MITRE Corporation was able to respond with highly flexible and creative systems-engineering solutions to software and hardware requirements implied by the instructional needs and goals generated by Texas and BYU The capabilities thus developed in turn stimulated the imagination of the developers at the universities. The research of the Texas Laboratory in learner control and in instructional design and packaging for computer-based systems provided a base of expertise in courseware development for CAI. The research in instructional psychology and instructional design and development at BYU provided empirical and theoretical perspective free from the self-limiting constraints which exist in yesterday's systems (in this case the IBM 1500 at Texas) but not in tomorrow's systems.

Because of a number of advantages at BYU, the director of courseware project at Texas, C. Victor Bunderson, his associate, Gerald W Faust, and half a dozen other key staff members elected to move to BYU in the summer of 1972. The Texas subcontract was terminated by MITRE because of the management and budget advantages of consolidation at BYU.

The TICCIT hardware, software and courseware was completed by the conclusion of the contract in June 1976. Substantial investment was required to complete this contract by MITRE, BYU and the two test community colleges -- Phoe[illegible] ollege of Arizona and Northern Virginia Community College of Alexandria These organizations completed the project at their

---

1/ U S Congress House Committee on Science and Technology Subcommittee on Domestic and International Scientific Planning, Analysis and Cooperation Computers and the Learning Society Washington, U S Govt Print Off , 1978 48 p (Hereafter cited as Computers and the Learning Society, Committee Print) own expense when the NSF funds proved insufficient for this ambitious undertaking and were not extended.

Hundreds of students began taking the TICCIT lessons in the fall of 1975 at the two community colleges. The system has been evaluated by Educational Testing Services at these two sites. Evaluation of TICCIT at the university level was undertaken starting in 1975 by the Computer Teaching Research Center at BYU. The ETS evaluation report is now in draft form and will soon be released. A series of evaluation reports are also available from BYU.

TICCIT Hardware. Large CAI systems like PLATO form a network of terminals connected to a powerful central computer by means of expensive telephone lines. By contrast, TICCIT was designed to serve a sizeable number of students in one location by means of inexpensive mini-computers.

Two Nova mini-computers can service 128 terminals at one campus site.

The color display terminals are an attractive feature of TICCIT. Using Sony color T.V. displays, TICCIT can present digitally-generated characters and graphics, on a grey background, in any combination of white, black, red, yellow, green, blue or blue-green. Free-form contours as well as computer-generated graphs can thus be displayed. The color and graphics are extremely powerful for prompting and cueing of various sorts. Pre-recorded audio messages can be switched, random access, to the terminals, as can short video-tapes originating from cassette players. A standard typewriter keyboard permits upper- and lower-case alphanumeric entry. Another special keyboard at the left permits cursor pointing and cursor movement with flexible editing. A set of special learner-control keys is available at the right side of the keyboard. The keyboard and the display capabilities are a reflection of the unique instructional theory behind the system.

TICCIT Software for Authoring. The crisp digital color displays with graphics are a hallmark of TICCIT, but the best display is useless without software tools to assist in authoring good courseware.

TICCIT software utilizes the color display hardware fully. Characters can be modified "on the fly" to produce any character set or to compose any graphic, whether describable easily by an elementary function or as a digitized version of free-form artwork. A modified television camera and graphics entry system scans and digitizes the artwork, which is then stored centrally. The graphics editor permits authors to plot any elementary or parametric function and to edit these and the digitized artwork at will.

Software to aid authors has taken a variety of forms. The graphics camera and editor is only one part of the vast interface designed to make the TICCIT computers easy for authors to use. The authoring system is more than an "authoring language" such as found on other CAI systems. Such languages are written to control the basic hardware and logical capabilities of a given CAI system. They do not include in their semantics the fundamental concepts of systematic instructional development, a growing body of knowledge used to develop the TICCIT courseware. An authoring system is an integrated set of computer programs, formatted manuscripts, and management procedures designed to facilitate the various steps in the instructional development process.

MITRE developed the operating systems, compilers, and related software for use by authors and students. Brigham Young University developed software to permit data entry and editing, graphics entry and editing, report generation for teachers and authors, and other user utility programs. Manuscript formats were developed for use by authors in producing maps, tests, objectives, rules, examples, practice problems, and helps and the same formats were embodied in the authoring software. Similar manuscript formats and on line embodiments for coders were developed to provide for display specifications, file creation, and answer analysis coding.

<u>The TICCIT Courseware and Instructional Theory</u>

The term "courseware" refers to educational materials, whether in the computer or associated with it (eg. handbooks). It should be distinguished from "software," which refers to computer programs to support authors, teachers, and students regardless of what courseware is being used.

The instructional model of learner control is a major contribution of the TICCIT project. The structured student language gives students control over the content of instruction by means of "maps" which allow the student to choose with few restraints any units and lessons to survey, then study. Students also control instructional strategy, by means of learner-control commands like "RULE," "EXAMPLE," "PRACTICE," and "HELP." Students receive help on strategy through an advisor program which gives them information designed to improve their learning strategies.

The learner control keys are tied to a theory of instruction which says that certain instructional components (like "RULES," "EXAMPLES," "PRACTICE PROBLEMS," "HELP's" and "MAPS") designed in a certain way, will promote learning. The evaluation of this instructional approach, both on TICCIT and on other media where it has been implemented, has been quite positive. The approach enables learners engaged in self-study to learn rapidly and well.

This is fortunate, since the model also leads to a systematic, efficient process for authoring materials that is highly cost effective compared to other methods of authoring. The authoring system first implemented on TICCIT is a major scientific and technological accomplishment.

This authoring system resulted in the production of a large body of courseware at Brigham Young University. Starting with a review of arithmetic, the mathematics materials extended from a review of fractions through elementary and intermediate algebra and elementary functions (except trigonometry). The English materials provide two catalog courses, a remedial grammar and mechanics course, and a freshman composition course, in which the teacher's role is vital in generating ideas and grading writing assignments, but not in teaching structure or editing skills.

This authoring model is now being used successfully by a number of companies who employ former TICCIT project staff members and at a number of colleges and training centers who employ TICCIT or BYU graduates. Several thousand segments of instruction using this approach have been developed beyond the 300 - 400 segments originally developed for the TICCIT community college projects. Most of these thousands of segments are on media other than TICCIT, which shows the generality of the instructional model.

APPENDIX 13

Description of the National Instructional Materials Information System (NIMIS) 1/

For the past three years we at Ohio State University have been engaged in the development of the National Instructional Materials Information System. NIMIS, as we know it, provides information on a wide variety of instructional materials which can be used in classrooms and other settings to educate handicapped children. NIMIS is a computer-based, on-line interactive retrieval system specifically developed for the purpose of assisting teachers, parents, and other educators in locating information about instructional materials. Such an on-line computer-based system enables individuals to "converse" with the computer. The individual asks questions by typing them on a computer keyboard and the answers immediately appear on a television screen.

NIMIS provides descriptive information concerning more than 35,000 selected instructional media and materials. The materials are the of four kinds: child-use instructional materials - materials used by the child or by the teacher and child interacting in the process of education, instruction, and evaluation. Secondly, teacher education materials - instructional materials used to prepare teachers to select, use, evaluate, design, and adapt media, materials, and educational technology for the special education of children with handicaps. Third, materials for measurement and evaluation - materials designed to provide for evaluation, assessment, measurement, and diagnosis of the current skills and abilities of the child with a handicap. And fourth, prototype materials - materials of an experimental or one of the [illegible] kind nature that have been developed as models for possible future development.

Most of the instructional media, materials, and educational technology in the NIMIS are non-print materials such as instructional kits, films, video cassettes, audio cassettes, filmstrips, games, toys, and other materials exploiting audiovisual technology for the special education of persons with impairments, disabilities, and handicaps.

NIMIS, with its 35,000 materials for special education, is only a small part of what is generally available. It is estimated that there are more than 300,000 instructional materials available commercially in 1974. In the previous twelve years this figure reflected an increase of 20.4% in textbooks, [illegible] in 16mm motion picture films, 700% increase in records, and [illegible] increase in filmstrips as well as innumerable audio tapes and cassettes, video tapes and video cassettes, overhead projection transparencies, multimedia kits, 8mm filmstrips, games and simulations. Unfortunately, all too few of these materials have been developed and

1/ U.S. Congress. House. Committee on Science and Technology. Subcommittee on Domestic and International Scientific Planning, Analysis and Cooperation. Computers and the Learning Society. Washington, U.S. Govt. Print. Off., 1978. 48 p.

tested with instructional effectiveness as a primary consideration. Even fewer have been specifically designed for use with persons who are handicapped. The descriptive information on instructional media, materials and technology included in NIMIS is expected to be accompanied by evaluative information. Currently, hard evidence and data are lacking on most materials. However, all materials in the present system have been selected by specialists in the education of the handicapped and most of them are accompanied by a statement such as, " ..evidence shows that this material is currently being used by teachers and educational programs (for the various disability groups)...." It is to be hoped that evidence of the effectiveness of instructional materials to achieve learners' objectives and teacher goals will be improved as the system develops.

THE NIMIS THESAURUS

Access to information stored in NIMIS is gained through special indexing terms called descriptors. These precisely defined terms are very important in retrieving information about instructional materials. There are more than 800 such descriptors included in the Instructional Materials Thesaurus for Special Education, 3rd Edition. The Thesaurus may be one of the most significant contributions of the NIMIS. The use of computer technology to aid teachers, parents, and students in the selection of appropriate instructional materials for handicapping conditions that have significance for education requires careful definition of terms, precision in language, and detailed specification of instructional objectives. Thus, the use of computers motivates a more objective and scientific approach to the special education of the handicapped than has heretofore been commonly practiced

INSTRUCTIONAL MANAGEMENT SYSTEMS

Among recent innovations in special education, making use of computer technology is the development of instructional management systems, instructional objectives banks or collections, and computer-based instructional support systems. These systems are designed to enable teachers to individualize instruction and to identify the instructional objectives, teaching techniques and related instructional materials needed to attain highly specific instructional goals. We recently queried more than 20 such systems to explore the possibilities for providing an interface between such systems and the NIMIS. Incomplete analysis indicates a wide range of sophistication in such systems, apparent duplication of effort, and the need for standards, criteria and guidelines for system development. Such guidelines should not be intended to reduce diversity nor to dampen creativity in innovation, but to maximize the possibilities for complementary and compatible systems and to facilitate their use of a national system like NIMIS.

APPENDIX 14

1/

14

THE Journal
Technological Horizons in Education
Vol. 4, No. 3

The Past, Present, and Future of Technology in Higher Education*

Harvey J. Brudner†

The following article written by a Senior Consultant to U.S.O.E. and former president of Westinghouse Learning Corp. is a paper which summarizes where we are, what the new technology now makes possible, and some predictions of where we are going in using instructional "hardware" for education. It follows up on an earlier paper written by Dr. Brudner ("Education—1984" T.H.E. Journal, Sept., 1975, pages 14–15). He is now a member of our advisory board.

This article will deal primarily with educational technology, and projects what some of the new videodisc technology can mean. It will review our current status with the emphasis being on computer-based instructional systems. The article will also make some predictions about the future and although some of its conclusions are similar to those in the 1975 article, the 2 year update has some surprises. It is interesting to compare this article as well with that of Dr. Molnar (Nov., 1975, pages 26–30 T.H.E. Journal), one of our contributing editors, since although from independent observations of the field they arrive at similar conclusions. We welcome your comments on their findings and encourage your development of short articles on the same topic.

Nothing — nothing at all — matters more than trained intelligence. It is the key not only to success in life, but it is the key to the meaning of life. — President Lyndon B. Johnson, Cotulla, Texas, November 1966.

Instructional processes in higher education basically have not changed during the past centuries, or even since the invention of printing. But a great change is likely during the next two decades. The technology of communications and data processing, which has had such a profound impact on American society in general will also start to exert a powerful influence on our system of higher education. The new technology has already begun to transform procedures in educational research, administration and large libraries. It has started to bring higher education to the handicapped, the sick, the aged, prisoners, and people located in remote areas.

Properly applied, the new technology increases the opportunity for independent study, and allows for a richer variety of courses and methods of instruction. These courses will include increased use of cable TV systems, videocassettes and videodisks, and computer-assisted and computer-managed instruction, as well as greater emphasis on multimedia learning kits.

The slow take-off of educational technology over the past decade suggests that there are many strong resisting forces. Obviously instructional technology is not completely welcomed by the academic community. This situation has been aggravated by the fact that faculty members with talent and interest to design new replicable learning materials are not always properly rewarded. Confusion has been generated by manufacturers offering incompatible systems of similar products, and there is the struggle between the local campus producers and the knowledge industry. Local projects often thrive even though faculty members may not have the combination of interest, subject-matter expertise, media knowledge, and learning-theory knowhow that high quality learning material design requires. The overall situation has been extensively reviewed in prior reports, such as the Report of the Carnegie Commission on Higher Education. This presentation reviews highlights from the best surveys,[1] and attempts to project future directions.

In 1967, Godwin Chu and Wilbur Schramm of the Institute for Communications Research of Stanford University concluded that, properly applied, the learning effectiveness of instruction provided by technology is as successful as that of good professors and teachers using conventional modes of instruction. The two authors reviewed 207 published studies comparing TV with conventional teaching. Of 421 comparisons, 308 showed no significant differences, 63 showed TV instruction superior, and 50 found conventional instruction better.[2] Similar findings for computer-assisted and programmed instruction have been developed by Levien.[3]

Many academicians ask, "Why should there be technology and media use in higher education?" From the students' point of view there are many reasons.

* This paper was first presented at the Conference on Innovation and Productivity in Higher Education, held at Carnegie-Mellon University on 14–16 October and is in the conference proceedings, published by San Francisco Press, Inc., 547 Howard Street, San Francisco, California 94105.

† Harvey J. Brudner is President of HJB Enterprises, Highland Park, N.J.

1/ U.S. Congress. House. Committee on Science and Technology. Subcommittee on Domestic and International Scientific Planning, Analysis and Cooperation. Computers and the Learning Society. Washington, U.S. Govt. Print. Off., 1978. 48 p. (Hereafter cited as Computers and the Learning Society, Committee Print).

Obviously no institution of higher education no matter how well endowed or publicly supported, can afford to cater to the diversified and specialized needs of the present generation of multidiscipline cross major students. Nor can even the strongest institutions offer 1 1 or even 1 5 teacher-to-student ratios. Moreover, students have come to expect personal and academic advising. Obviously more of the professor's time in the future will have to go into advisory and managerial roles and less into tutorial roles. It is precisely in the latter area that technology and media can play a quality role.

Flexible, modular scheduling easily generated by computer systems can expand learning options for the working student and even generate adapted time payment and credit spread schedules. Also electronic and audiovisual developments allow the multicampus institution to extend available faculty talent of unique qualifications to remote locations. A trend may well develop to encourage nonresearch oriented faculty and professional staff members to produce technical materials via the new media.

Observations on the Present-day Status

Most examples of present-day educational technology are overly familiar to us. Books, for example, are basically technological learning devices so are blackboards, maps, models, charts, and specimens. The stereograph dates back to 1885, the lantern slide, to 1900. Motion pictures were used for education as early as 1910 and radio, starting in Pittsburgh, in the 1920's. The early 1960's brought closed-circuit TV and the multimedia classroom; the mid-1960's, computer-assisted and (a little later) computer-managed instruction; and the 1970's, the videodisk.

The techniques have been improved and refined each year. Microfilm and microfiche are examples of high-density reduction technology. Dry copying has had considerable impact, so has electronic reproduction and facsimile telecommunications and reproduction. All that is no longer regarded with amazement on the college campus.

Indeed, although motion pictures are reaching their 70th year of educational use, colleges use them rather infrequently for instruction. Seeking out, acquiring, and setting up a good film is regarded as an annoying chore by the typical professor, whose department chairmen probably regards films as relatively expensive and annoying in that the class may have to be moved or rescheduled and arrangements may have to be made for a projectionist. Most universities use 16mm films, but Super 8mm film has started to make an impact. The history of 8mm films, first commercially introduced in 1932, goes back almost as far as 16 mm; it began as an amateur product for the general public, but in the early 1960's several companies introduced 8mm sound projectors and then, in 1965, introduced the new Super 8mm format. The loop projectors have found use in education in present short-film segments in "single-concept" format and have found additional application for students to study independently.

Much of the technology used in large multimedia classes is also used in self-instruction units. Indeed, the growth of *individualized instruction* represents education's most significant trend even though it is still in its infancy.

The 1960's saw many installations of language laboratories.[5] Here, via audiotape lessons, individualization of instruction goes on with the teacher at the master console acting to monitor and guide each student on his or her own learning path. The Philips type of audiocassette has made further development of the audio listening center as a relatively available and cost-effective approach possible, yet relatively few college departments have implemented the audiotutorial concept. Implementations such as those at Carnegie-Mellon and Purdue Universities remain exceptions.[6]

Another refinement of the concept is the utilization of computer equipment and telephone lines to select and deliver audio and audio-visual instruction via materials held at a central storage center. To date such dial-access systems have proved to be too expensive and too limited in their software to be widely disseminated.

Radio broadcasting of lectures and instruction was at one time thought to be a major opportunity. By 1968 the original Ohio State University station that helped spearhead the program was only transmitting two programs a week to schools. Not even the availability of millions of car radios and transistor radios has changed this pattern. By 1970 only 12% of the originally licensed educational AM radio stations were still in existence however, almost 500 capus FM radio stations serve local schools[7] Such stations generally have a broadcast radius of only a few miles, and only 10% of them are used primarily for instruction Yet radio has been extensively used in South Korea, Japan and Great Britain for delivering education to remote areas In the United States, only specialized networks such as those used for postgraduate medical instruction have found continuing application New York State (via the SUNY-Albany facility) North Carolina Utah California, Wisconsin, and Ohio are among the best-known operators.[8]

Television has perhaps the greatest and most pervasive potential of any instructional technology It comes in many forms, with various potentials and limitations. Most dynamic has been broadcast TV via public television networks Such series as Masterpiece Theatre, Civilization and The Ascent of Man have attracted wide audiences and have had considerable impact in continuing education Another success is NYU s Sunrise Semester Yet relatively few colleges and universities have been able to maintain broadcast facilities for instruction Chicago City College and the Open University systems of Great Britain and of Japan are oft-cited examples however only about 30% of the instruction in such programs takes place by broadcast TV

The clo ed-circuit or cable systems increase the range of instruction, and enable colleges to schedule instruction better The so-called Instructional Television Fixed Service (ITFS) is a distribution system whose broadcasts at microwave frequencies are picked up with special receiving equipment for redistribution within say a school building The range is limited to about 25 miles which is more than adequate for most college and university systems However, most ITFS systems are used by elementary and high-school districts, and by parochial-school systems

The Community Antenna or Cable TV systems are extended counterparts of campus-wide closed-circuit television systems[8] Here specially de igned antennas or high towers or mountain peaks pick up distant TV signals, amplify them and redistribute them over special (usually coaxial) cables to homes businesses and schools The importance for higher education rests largely in the large number of channels that are available

We may divide recent nontraditional programs into those which provide a highly personalized and individualized form of education and those which offer flexible access to courses through teaching at a distance The personalized programs include that of Minnesota Metropolitan State College the University Without Walls consortium and the Empire State University of New York (now with about 3 000 students)[10,11]

The New York State Regents program offers bachelor s degrees solely on the ba is of examination and transfer credits at present in nursing and business administration without residence on a campus and without formal course registration[12]

We have also seen the use of the modified British Open University (teaching-at-a-distance) system in the United States at Rutgers University, the University of Maryland and the University of Houston These programs enable students to undert a serious college-level study without the requirement of sche ing classes[13] The Coast Community College in California has been a leader in the development of courses which utilize broadcast TV[14] and the University of California at San Diego Extension Division has created the idea of using special materials published in daily newspapers as a basis for course development[15]

One of the most important recent programs has been that of the University of Mid-America (UMA) a consortium of seven large midwestern universities Iowa State, Kansas State and the Universities of Nebraska Missouri Kansas Iowa and South Dakota UMA carries out three major functions

(1) preparation of multimedia courses
(2) coordination of learning activities in the participating institutions and
(3) research in the effects of various kinds of media presentation

Although still young with about 2,000 students it has completed a course in Accounting and is working on courses as varied as Japan The Great Plains World Food Problems, Poetry, and Application of Pesticides

Another interesting program, operating out of Evanston, Illinois is the Learning Exchange a matchmaker organization to bring together individual teachers and learners for given subject fields in such a program learners then have an obligation to teach in the field in which they are qualified[16] The above programs and others were recently reviewed by UMA s J I Lipson at an Interciencia conference in Brasilia[17]

Many programs can be carried, some quite specialized and of interest to only a few people Cable TV thus begins to approximate the dial-access capability mentioned earlier

The latest TV refinements are videotapes and videocassettes, which permit storage of instruction for repeated, convenient use In some institutions such as Oral Roberts University in Oklahoma tapes can be checked out or called up for viewing on special monitors Some institutions have made use of such capabilities in conjunction with TV cameras to record classroom performance of student teachers speech therapy students athletes musicians etc and have instant playback and analysis[18] In 1973 Kremer and Compaan (of the Philips Corp in the Netherlands) wrote Although no other mass medium has undergone such rapid growth or made such an impact as television it is technically true to say that in many respects it is still in its infancy They went on to describe their new laser videodisk system, appropriately called On Printing Motion "[18]

Sociologists tell us that Americans watch on the average of over 30 hours of TV each week The public in general (including students) has acquired a liking for it What would be the impact of systems that would allow

System	*Philips/MCA*	*RCA*
Price of unit	$500	$500
Price of disk	Somewhat above LP costs for 12 in., 30 min disk	$10 for 12 in., 60 min disk
Playing time of 12 in. disk	30 min (recorded on one side only)	60 min (recorded on both sides)
Features	Picture can be speeded up slowed or frozen Finger prints dust do not distort Disks can be made thick or thin including a paperthin one to be sent through mails	Use of a grooved disk eliminates two of the control systems needed for optical systems Production costs are lower Slower rotational speed reduces vibration problems
Recording system	Laser beam	Electron beam
Disk material	Plastic coated with aluminum and transparent protective layer	Vinyl copolymer coated with metal dielectric and lubricant
Speed of rotation	1800 rpm	450 rpm
Life of pickup element	Approx 10 000 hr	500 hr
Manufacturers	Philips & Magnavox (player) MCA & Plyogram (disk)	RCA

ter freedom of choice of program — as we have with books or records — at about the same price?

Unfortunately, magnetic tape is relatively costly and not too easily handled which makes duplication complicated and program access somewhat slow We are used to audio information being "printed" on records why not have low-cost TV information printed on records? Utilization of laser technology for both master generation and playback could lead to such a "printed system" The Philips Video Long-Play (VLP) disk has an optical readout (via a small helium-neon laser in the playback unit) It is therefore easily repositioned and can produce

- a still picture
- variable speed motion
- forward and reverse motion
- address readout of any one of the 54,000 frames in the 30 min disk
- sequenced or computer-controlled readout

The following table compares per copy manufacturer's materials costs for a 30-minute motion visual program

Medium	*Quantity* 1	10	100	1000
16mm film	$417	$108	$84 52	$66 17
8 mm film	285	66	52 00	44 76
¾ in videocassette	70	31	21 25	18 50
Videodisk (projected)	450	46	3 01	0 63

Because of the high quality of the TV picture one can even use the frames to store print and index banks We shall return to this interesting development after a brief review is made of the related developments in computerized information systems

Recently, RCA Corp has adopted a new technique to produce a videodisk that can be played via a capacitive readout There are many similarities of intent between the Philips and RCA systems, but technologically they are quite different and probably only one of them will ultimately prevail The RCA videorecord is also 12 in in diameter, however as in an ordinary LP record a metal-tipped sapphire stylus rides in the record groove, senses tiny changes in electrical capacitance along the groove, and utilizes these changes to modulate the signal The RCA record can be therefore recorded on both sides to produce an hour's output The above table (adapted from Forbes Magazine[21]) compares the two formats.

Computer Systems

Computers can be involved in higher education in many ways.[22] Computer-assisted programmed instruction (CAI) has received most attention. Here the computer system is used as a medium to present instruction directly to the student. Obviously, the computer attempts to assist or substitute for the instructor. We define programmed instruction as learning programs structured in terms of defined behavioral goals.

Time-shared CAI systems are available today at moderately high cost, several hundred dollars to $1000 per month per terminal. Until recently most CAI terminals have consisted merely of teletypes or typewriters. Such equipment, with associated communication gear, typically accounts for one-third to one-half of the costs of a system with a full complement of terminals. Cathode-ray-tube display terminals are beginning to replace the typewriter for many purposes. More advanced terminals, such as plasma displays with a variety of audiovisual features, are also coming into use, and even more advanced laboratory prototypes offer great promise for future low-cost, high-function terminals. In short, development of terminals is a long way from a standard terminal for CAI.[23]

Several programming languages and operating systems for supporting CAI work have been developed. With a few exceptions, each of these systems is oriented either toward conversational programming as a means of problem solving or toward use of a CAI language for more or less stylized programmed instruction. Of the systems now seen, none seems to be fully adequate possibly as an early prototype of a future CAI operating system.

As to instructional programs for CAI, experience to date shows that program preparation costs range from several hundred to a few thousand dollars per student hour. It is not yet clear how much an instructional hour will be worth in comparison with an hour of alternate learning activity. There is not even agreement on how to estimate eventual cost effectiveness of CAI.[24] There is urgent need for some good evaluation experiments to lay a foundation for cost-effectiveness evaluation. Some CAI programs consist of mere presentations and/or simple questions-and-answers testing, in short, of materials from some other medium displayed by means of a computer terminal.

The chief deficiency in most programs is not that the content is mundane or the sequencing of learning objectives conventional; elementary content can be quite suitable for CAI, and conventional structuring of the program content is usually valid. The fault is rather that poor use is made of the computer. To discuss this point adequately, we distinguish (following Adams[25]) among three technical aspects or dimensions of design of a learning program: content, structure, and mediation.

Content means something like the scholar's notion of the scope of the course, the corpus of information in it — in behavioral terms, the terminal objectives. *Structure* means the elements of order that make it a program in the learning psychologist's use of the term: the strategy of building up a complex skill, the hierarchy of behavioral objectives, the play of sequencing of learning tasks, the forms of messages, the esthetic value of the learning experience. A successful CAI program must succeed in both content and structure. However, if the learning program is to be deemed successful as CAI, the computer's function must be essential to the realization of some important instructional value. Clear identification of the value added by the computer should be the first step in the evaluation of a CAI program.

Although the computer is often regarded primarily as a communications medium, it can contribute to any of the three aspects of the program. It may contribute to content where the learning tasks involve formulation or use of computer programs as such. It may be essential to structure where the sequencing of learning tasks depends on the past experience of the individual student. It may contribute *mediation* values where immediate responsiveness improves the effectiveness of the learning program or where computer mediation permits changes in administration and/or logistics of instruction.

What we need is a set of established programming principles for preparing learning tasks that are suited to the medium. For example:

- Constructed responses are usually better than selected responses.
- Learner initiative and control are desirable features.
- Instructions should be held to a minimum; tasks should be formulated so that there is a "natural" way to answer, and so that the computer can deal with minor format variations.
- Service messages (correct, wrong, etc.) should be in general as few and as brief as possible.
- Where appropriate, programs should facilitate trial-and-error learning.
- Clarity should come before enrichment.
- It is more important for the learner to know what he is doing than for the learning psychologist to foresee and control the process in detail.

The unique promise of CAI is to give a learner conversational interaction with a body of information especially structured for facilitating learning. The extent to which this promise can be fulfilled at present is limited more by poverty of programming technique than by the other technical limitations of the CAI systems. The foremost educational need for advancing the state of the art in CAI is thus to develop and demonstrate program designs and learning tasks that achieve effective communication between learner and learning programs.

That is not to say that there are not also great needs and opportunities to tie together CAI with new au-

audiovisual techniques such as the laser videodisk. Such systems may ultimately allow low-cost, branching audiovisual CAI formats.

Apart from the tutorial mode and the more obvious uses in simulations, demonstrations, gaming, etc., the computer can be very valuable in the management of the total instructional process. Such techniques lead to what has become known as the Computer-Managed Instructional (CMI) system.[26] Here, as in the Westinghouse Plan* system, an electronic data-processing system becomes an aid to the teacher or professor. The computer enhances instructional efficiency. In a 1972 survey, Comstock found that the most common use is data processing and teaching computer science.[27] Fewer than 10% of present-day universities and colleges report any form of tutorial use, for various reasons: (1) the faculty is not well aware of the instructional potential of the computer, (2) effective and validated instructional software is lacking, or (3) most present systems (except in specialized areas) are not cost effective.

One of the best-known surviving systems is the University of Illinois PLATO series, now in its PLATO IV generation.[28] It is conceived to handle eventually some 4000 teaching stations. At the present time an estimated 15 000 part time students take at least some of their courses on a screen display, by printout, or (in some test situations) by synthesized speech. In April 1976 Control Data Corp., which builds the Cyber computer series utilized by PLATO, announced that a major commercial push was expected with additional customers among universities and in the military, however, the primary target was to be industrial training.[29] PLATO systems are being installed by universities in Florida and Quebec, and a modified package at Lowry Air Force Base in Denver, but the major thrust will be to offer industry terminals at $15/hr per student. PLATO promotors argue that it costs $5-10/hr to educate an undergraduate, $20-30 for a graduate, and $30 and up for a professional student. There will be no attempt initially to offer the system to secondary schools, since a typical school allocates about $1/hr for each student.

The designers claim that PLATO design overcomes some of the problems of earlier CAI systems. Instead of storing data on magnetic tapes or disks, PLATO relies on more conventional extended core memory, which allows data to be moved out of storage as much as 1000 times faster. Therefore, even when 500 terminals share one central processing unit, a student need wait only 0.2 sec, on the average, for a response. Earlier CAI systems had long response times and some students lost interest as a result.

The PLATO display consists of a grid of fine wires, 512 across and 512 down, sandwiched between two plates of glass so that the wires form a grid of more than 250 000 tiny cubicles, each containing neon gas. When a cubicle is addressed by the computer keyboard, a surge of current causes the gas to ionize and glow. The display is free of flicker, unlike a cathode-ray tube. It need not be "refreshed." Because it is transparent, slide pictures can be superimposed on the display. However, the plasma display panel accounts for about 35% of a terminal's cost of about $6000 at present.

Critics of the centralized approach point out that phone tarriffs are on the rise and microcircuitry costs are coming down, making it economically feasible to put more and more computer power and memory into stand-alone minicomputer systems. The leading manufacturer of minicomputers, Digital Equipment Corp., has already sold over $12 million worth of minis to colleges and universities.

Several colleges and universities are now employing time-sharing services of a computer consortium, such as the Dartmouth Regional Consortium and the Oregon State Regional Computer Center. Basically such consortia require only the installation of terminals and telephone communications lines.

TICCIT (Time-sharing Interactive Computer-Controlled Information Television) was developed under a National Science Foundation contract by the MITRE Corp. of Boston and Washington, a nonprofit systems-engineering company. Courses were developed by the Institute for Computer Uses in Education at Brigham Young University (BYU). TICCIT was originally intended for use in community colleges, according to C. V. Bunderson, director of the BYU Computer Institute.[30] However, among its first users are U.S. Navy training programs in California and Florida.

Formal field tests of TICCIT have been conducted at Maricopa Community College in Phoenix and at Alexandria campus of Northern Virginia Community College.

The Future

The author and many of his colleagues feel that technology and media can and will make significant contributions to the future of higher education. We have witnessed many examples over the past decade in which the computer enhanced the individualization of instruction and enabled the professor to adapt instruction to the personal needs of students. Computer use to help manage the process looks promising, and as the costs of both central processing hardware and of terminals decrease, this approach will be applied more extensively. A corresponding development of technology is expected to carry education outside the school and university center to the home and community, and to business and industrial centers.

With future uses of cable systems, it will be possible to put the most disadvantaged students into contact with the most advantaged resources. Much of one's education already takes place outside the classroom. In the future, it should be increasingly possible to guide that learning by the use of technology.

A recent article in the *Wall Street Journal*[31] reassesses educational trends as follows: (1) increasing demand for continuing education, (2) more flexibility in the content and structure of education, (3) more use of computers in education, (4) use of videodisks, (5) more use of communications and multimedia, (6) training and education approaching 12% of the gross national product, (7) productivity increases, (8) more use of low-cost open structures, (9) growth of learning centers, (10) weekend colleges patterned after Mid-America University, (11) Federal support of education increasing to 30%, (12) more emphasis on the development of values, (13) more use of video-packaged education, (14) increased use of testing and a trend toward criterion-referenced testing based on specific objectives, (15) increasing student expertise in computers and personal portable calculators, and (16) the price of minicomputers dropping from $10 000 to $1 000 over the next several decades. The only "negative" in this futurecast indicates that the percentage of our high-school graduates who go on to formal higher education will not rise above 50% (compared to the present 47%).

How soon these trends may be realized has been the subject of speculation by Silberman[32] and by the author.[33] Boulding has pointed out that the schooling industry is supported mainly through one-way grants rather than by the sale of services in an open market, and consequently has little incentive to increase its productivity. He writes about alternative techniques for solving the problem, such as a voucher plan that would reward schools that achieve greater productivity, and educational banks that would lend students the full costs of their education — with the loans to be paid by an income-tax surcharge. He argues that if education is converted to a market economy, it might be easier to establish a market to support private technological developments.

In the next decade, we shall experience an ever-increasing number of changes that will transform our lives and the world of education. New mathematical development, new science, new social science and new technology will be upon us with accelerating speed and intensity.

The new technology will include microcomputerization, laser applications, more abundant power sources, more sophisticated biomedics, extensive use of satellite telecommunications, and the beginnings of a "science of leadership." In the future, each student will receive instruction according to his or her individual needs. Students will learn at their own paces, using materials and presentational systems that fit the cycle of development. Computer systems will help teachers in teaching students and diagnostic testing, but instruction will still remain under teacher control. Students will learn to take greater responsibility and make independent decisions. Critical, analytic thinking will be stressed, and students will have more freedom and use it to increase their problem-solving abilities. They will work as individuals and in small groups directly with their teachers. Teachers will not be required to write lesson plans since learning objectives and guides will have been fashioned for all subjects. Instead, teachers will spend time developing special interdisciplinary objectives and activities for a particular student or situation. Besides traditional homework, more time will be spent doing interactive lessons with one's parents and members of the family.

Illich has proposed that we devote more energy to making it possible for people to learn in informal settings of their normal daily activities without mediation by schools or professional educators.[34] He argues that since the cost of education is rising faster than the productivity of the entire economy, it would be cheaper to give people more personal responsibility for what they learn and teach without the aid of professionals. His first step toward opening the access to skills would be to provide incentives for skilled individuals to share their knowledge. He suggests computerized match-makers to match peers, form tutor/student combinations, and create learning webs.

An important Delphi technique[35] Study of Factors That Have Inhibited a More Widespread Use of Computers in the Instructional Process was done by EDUCOM (the Interuniversity Communications Council) in 1972. It contained fifteen recommended action plans as suggested directions for breaking the status quo cycle.

Clearly, education will be increasingly broadened through vocational and technical training.[37] We have witnessed these trends already at the community college level. As Lester Brown has put it, "We may be on the verge of one of the great discontinuities in human history. Those who think the final quarter of this century will be merely an extrapolation of the third will be seriously disillusioned."[38]

Our children will spend more than half their lives in the 21st Century! In 1984 there will be a population of about one hundred million Americans aged 3 to 24. The occupation for most of them will be student. Extrapolations of present trends indicates that expendtures for education and training may then reach $100 billion a year in 1976 dollars

The resources for a considerable transformation of higher education will be therefore available over the next 25 years. Many are looking forward to participating in the implementation of these exciting new discoveries.[39] ■

References

1 Eric Ashby, R M Besse, et al., *The Fourth Revolution* (Carnegie Commission on Higher Education), New York, McGraw-Hill, 1972

2 *Ibid.*, p 13

3 R F Levien, *The Emerging Technology. The Instructional Uses of the Computer in Higher Education*, New York, McGraw-Hill, 1972

4 J W Thornton Jr and J. W Brown, *New Media in Higher Education*, Washington, D.C. National Education Association, 1967

5 Thomas Hope, *The Hope Reports Perspective* (Rochester, N Y.) (No. 4) 2-7 March 1976

6 W H Allen and D H. Coombs, *Trends in Instructional Technology*, Stanford, Calif. ERIC-Stanford Planning Report, 1970

7 S. C Tickton, Ed. *To Improve Learning. An Evaluation of Instructional Technology*, New York, Bowker, 1970-1971, 2 vols

8 R O Forsythe, *Instructional Radio*, Stanford, Calif., ERIC-Stanford, 1970, p 3.

9 Carnegie Commission on Educational Television, *Public Television A Program for Action*, New York, 1967

10 Norman MacKenzie, Richmond Postgate and John Scupham, *Open Learning: Systems and Problems in Post-Secondary Education*, Paris, UNESCO, 1975.

11 C O Houle, *The External Degree*, San Francisco, Jossey-Bass, 1973

12 K P Cross, Personal conversation with Joseph Lipson, 1976

13 C E Covert, Ed. *Proc. First Annual National Conf. on Open Learning in Higher Education*, Lincoln, Neb. University of Mid-America, 1974, p 619

14 *Ibid.*, p 113

15 *Ibid.*, p 131

16 R Martin and E J McCartney, "The Future Revised," *Wall Street J.*, 8 April 1976 pp 1, 27

17 J L Lipson, "The present state and evolution of nontraditional postsecondary education," paper presented at Interciencia Conference, Brasilia, 13 July 1976

18 Department of Audiovisual Instruction, *A Survey of Instructional Closed-circuit Television*, Washington, D C. National Education Association, 1967

19 P Kramer and K Compaan, "On printing motion," *Ideology Magazine*, 1 April 1973 (Reprinted *Philips Technical J.*)

20 E W Schneider, *Educational Technology*, Englewood Cliffs, N J. Prentice-Hall, 1976

21 "The new television," *Forbes Magazine*, 1 June 1976, pp 24-29

22 A G Oettinger and Selma Marks, *Run, Computer, Run*, Cambridge, Mass. Harvard University Press, 1969

23 Jeremy Bernstein, *The Analytical Engine*, New York, Random House, 1966

24 M B. Solomon, "Some computer economics in education," *Educational Technology* (No 5) 47-48, 1971

25 E N Adams, *Project ARISTOTLE Report*, Washington, D C. NSIA, 1966

26 H J Bruder, "Computer-managed instruction," *Science* 162, 970-976, 1968.

27 G A. Comstock, "The computer and higher education in California," in Ref 3.

28 D L. Bitzer and D Skaperdas, *The Design of an Economically Viable Large-scale, Computer-based Education System*, Urbana, Ill. University of Illinois, 1969; also see *Science* 192, 334 (1976)

29 "More teaching by computer," *Business Week*, 26 April 1976, pp 66-B-66-S.

30 T Magarrell, The Chronicle of Higher Education, 26 April 1976, Vol. XII, No. 9, p 1

31 Ref 16

32 Harry Silberman, "The Educational potential of technology," speech presented at UCLA Faculty Lecture series, 1973.

33 H. J Bruder, "Education — 1984," *Technical Horizons in Education* 14-15 September 1975, Vol 2, No. 5

34 K E Boulding, "The School industry as a possible pathological section of the American economy," *Rev. Educ. Res.* 41, 1, 11 129-143, 1971

35 Ivan Illich, *Deschooling Society*, New York, Harper and Row, 1971

36 E J. Anastasio and J S. Morgan, *A Study of Factors That Have Inhibited a More Widespread Use of Computers in the Instructional Pr[illegible]*, ETS Grant NSF GJ7 1827 Interuniversity Communic[illegible] Council, 1972, pp 36-49

37 K B Hoyt, "Broadening education through vocational and technical training," *Implications for Measurement* (Proc. 1971 Invitational Conf. on Testing Problems), p 113

38 L R Brown, *U S News and World Report*, 3 March 1975, p. 32

39 Ref 33.

APPENDIX 15

"Information Technology in Education Demonstration Program" Participants 1/

PARTICIPANT INFORMATION

1. **Demonstrator:** Association for Media-based Continuing Education for Engineers, Inc. (AMCEE)
c/o Colorado State University
College of Engineering
Fort Collins, CO.

Title: "Coordinated University Programs in Engineering Via Video"

Subject Matter and Educational Implication:

Various engineering disciplines and selected applied sciences and management subjects taught through the use of videocassettes. Such a system allows for convenient, flexible, on-the-job study opportunities and credit-bearing courses to be made available to engineering students in the AMCEE consortium.

Target Audience: Engineers and technical managers in continuing and graduate education environments.

2. **Demonstrator:** Computer Corporation of America
1600 Wilson Blvd., Suite 903
Arlington, VA. 22209

Title: "Microcomputer-based Simulation in Training"

Subject Matter and Educational Implication:

Displays interactive simulations of war games, electronics trouble shooting, and models of student procedural errors. The systems to be shown are low cost, low fidelity, real-time simulations that are feasible with existing microcomputer technology and demonstrate on a broader perspective the generative nature of student errors.

Target Audience: Continuing education students.

3. **Demonstrator:** Domestic Information Display System (DIDS)
Department of Commerce
OFSPS
2001 S St., N.W.
Washington, D.C. 20009

Title: "Domestic Information Display System"

Subject Matter and Educational Implication:

Provides interactive colorgraphic presentations of statistical data that could be used as teaching tools for such subjects as statistics, political science, geography, urban/rural planning, computer sciences, and social sciences. Theories and relationships between data can be formulated and reviewed by students using such a system.

Target Audience: Government policy analysts and decisionmakers (potential for higher education students and education managers).

1/ U.S. Congress. House. Committee on Science and Technology, Subcommittee on Science, Research, and Technology, and the Committee on Education and Labor, Subcommittee on Select Education. Information Technology in Education. Hearings, 96th Congress, 2nd session. April 2, 3, 1980. Washington, U.S. Govt. Print. Off., 1980. p. 233-237.

4. __Demonstrator:__ Hazeltine Corporation
7680 Old Springhouse Road
McLean, VA. 22102

__Title:__ "TICCIT Computer-based Training"

__Subject Matter and Educational Implications:__

Designed to be a criterion-referenced, self-paced instructional tool to provide basic skills in math, grammar, and reading for junior college and university-level students and operations or maintenance instruction for military applications.

__Target Audience:__ Remedial students in higher education and military aviation personnel.

5. __Demonstrator:__ Minnesota Educational Computing Consortium (MECC)
2520 Broadway Drive
St. Paul, MN. 55113

__Title:__ "Microcomputers as Instructional Aids"

__Subject Matter and Educational Implications:__

Focuses on computer applications for elementary and secondary students where the computer is an instructional tool used by teachers in a classroom setting or individual students working independently with the computer. Simulations, tutorial exercises, drill-and-practice lessons, and data retrieval on such topics as language arts, elementary science, music theory, art, algebra, social studies, and driver education will be shown.

__Target Audience:__ Elementary, secondary, and higher education students.

6. __Demonstrator:__ National Captioning Center
5203 Leesburg Pike
Falls Church, VA. 22041

__Title:__ "Closed-captioned Television"

__Subject Matter and Educational Implications:__

Presents a working model of closed-captioning of television programming that is designed to benefit hearing-impaired persons. Such a system also can be used to aid children with learning disabilities.

__Target Audience:__ Hearing-impaired persons and children with learning disabilities.

7. **Demonstrator:** SUNY at Stony Brook
College of Engineering
Stony Brook, N.Y. 11794

Title: "Microcomputers and Learning Environments"

Subject Matter and Educational Implications:

Presents such programs as simulations, drill-and-practices, and games in mathematics, science, language arts, and music. In addition, a new communications device for the neuromuscularly handicapped that can interact with computers and other segments of the person's environment, will be demonstrated. Such a microcomputer-based learning experience takes advantage of the discovery mode of learning, promotes computer-based learning over conventional teaching methods, and presents educational lessons and concepts in a new and creative way.

Target Audience: Kindergarten through higher education.

8. **Demonstrator:** University of California — Irvine
Educational Technology Center
Irvine, CA. 92717

Subject Matter and Educational Implications:

Primary emphasis on scientific literacy, physics, and statistics taught through the use of microcomputers. Major advantages to such a system are (1) the student is in an interactive learning environment and (2) the learning experience is individualized to each participating student.

9. **Demonstrator:** University of Delaware
PLATO Project
Newark, DE. 19711

Title: "Applications of a PLATO Computer-based Educational System"

Subject Matter and Educational Implications:

Demonstrates varied topics with an emphasis on physical and social sciences, arts and humanities, health applications, and basic skills. Plato provides a highly flexible learning system with considerable human engineering factors, graphic displays, and interactive capabilities designed into the learning process.

Target Audience: Kindergarten through higher education.

10. **Demonstrator:** Utah State University
Exceptional Child Center and
Center for Instructional Product Development
Logan, UT. 84322

Title: "Microcomputer/Videodisc for Interactive CAI for the Mentally Handicapped"

Subject Matter and Educational Implications:

Presents computer-assisted instruction of various language arts and reading programs through the use of videodisc technology. This type of teaching method departs from the traditional CAI learning programs since presentations are made in non-written formats, thus benefiting non-readers. The Nebraska ETV Network videodiscs explore the limits to which interactive videodiscs can be used in individual instruction (Spanish pronunciation at the secondary level) and group instruction (basic tumbling skills at the elementary level).

Target Audience: Mentally handicapped and non-readers of all ages.

The Subcommittees and demonstrators appreciate the cooperation of the following organizations in providing necessary equipment and services for the demonstration program:

Defense Advanced Research Projects Agency
U.S. Department of Defense

Department of Engineering
University of Maryland
College Park, Maryland

Division of Educational Technology
U.S. Department of Health, Education, and Welfare

House Information Systems
Committee on House Administration
U.S. House of Representatives

Tektronix Inc.
Rockville, Maryland

Terak Corporation
Scottsdale, Arizona

APPENDIX 16

Selected References

Written treatment of the interdisciplinary field of information technology in education has expanded significantly during the past decade. The literature, ranging from pamphlets and technical publications to books and specially commissioned overview studies, is the product of a multifaceted community: congressional overseers, executive branch program managers, academe, lawyers and librarians, information systems conceptualists and implementers, educational administrators and instructors, and user groups.

In order to facilitate utilization of this bibliography, the selected source items have been organized into two major categories:

(1) Congressional documents--reports, studies, records of hearings, compilations of papers, and bibliographies (arranged by year).

(2) Non-legislative branch publications—books, conference proceedings, studies, reports, bibliographic guides, glossaries, and encyclopedias.

CONGRESSIONAL DOCUMENTS 1/

1965

U.S. Congress. Senate. Committee on Labor and Public Welfare. Subcommittee on Education. White House conference on education. Committee Print, 89th Congress, 1st session. Washington, U.S. Govt. Print. Off., 1965. 217 p.
L106 1955 .W3232

1966

U.S. Congress. Joint Economic Committee. Subcommittee on Economic Progress. Technology in education. Hearings, 89th Congress, 2d session. Washington, U.S. Govt. Print. Off, 1966. 273 p.
LB 1027 .U55

U.S. Congress. Joint Economic Committee. Subcommittee on Economic Progress. Automation and technology in education. Joint Committee Report, Washington, U.S. Govt. Print. Off., 1966. 11 p.
LB 1028.5 .U52

1968

U.S. Congress. House. Committee on Government Operations. Operations of Office of Education (Conflict of interest—proposed grant for computerized classroom). House Report No. 1834, 90th Congress, 2nd session. Washington, U.S. Government Print. Off., 1968. 33 p.
L 112 .A42

1969

U.S. Congress. House. Committee on Foreign Affairs. Subcommittee on National Security Policy and Scientific Developments. Satellite broadcasting: implications for foreign policy. Hearings, 91st Congress, 1st session. Washington, U.S. Govt. Print. Off., 1969. 317 p.
Hearings held May 13, 14, 15, and 22, 1969.
KF 27 .F6 4831

1970

U.S. Congress. House. Committee on Education and Labor. General Subcommittee on Education. Needs of elementary and secondary education for the seventies. Hearings, 91st Cong., 1st. session, on H.R. 517 and others. Washington, U.S. Govt. Print. Off., 1970. Part 1, 604 p.
Hearings held Oct. 2, 8, 9, 14, 15, 16 and Nov. 12, 1969.
KF 27 .E333 1969f

U.S. Congress. House. Committee on Education and Labor. General Subcommittee on Education. Needs of elementary and secondary education for the seventies. A Compendium of policy papers. Committee Print, 91st Congress, 1st session. Washington, U.S. Govt. Print. Off., 1970. 982 p.
LB 2825 .N43

1/ Unless otherwise noted, hearings sessions were held in Washington D.C.

U.S. Congress. House. Committee on Education and Labor. A report to the President and the Congress of the U.S. by the Commission on Instructional Technology. To Improve learning. Committee Print, 91st Congress, 2nd session. Washington, U.S. Govt. Print Off., 1970. 124 p.
LB 1043 .A45

U.S. Congress. House. Committee on Education and Labor. Select Subcommittee on Education. Educational technology act of 1969. Hearing, 91st Congress, 1st session. Washington, D.C., U.S. Govt. Print Off., 1971, 184p.
Hearings held in Washington, D.C., Mar. 12, 1970. KF 27 .E335 1970g

U.S. Congress. House. Committee on Foreign Affairs. Subcommittee on National Security Policy and Scientific Developments. Foreign policy implications of satelite communications. Hearings, 91st Congress, 2d session. U.S. Govt. Print. Off., 1970. 212 p.
Hearings held April 23, 28, 30, 1970. KF 27 .F6483 1970b

U.S. Congress. House. Committee on Foreign Affairs. Subcommittee on National Security and Policy and Scientific Development. Reports of the special study mission to Latin America on military assistance training and developmental television. Committee Print, 91st Congress, 1st session. Washington, U.S. Govt. Print. Off., 1970. 53 p.

U.S. Congress. House. Committee on Labor and Public Welfare. Subcommittee on Education. Higher education amendments of 1970. Hearings, 91st Congress, 2d session, on S. 3474. Washington, U.S. Govt. Print. Off., 1970. 895 p.
Hearings held Feb. 5; May 12 and 21, 1970. KF 26 .L343 1970g

U.S. Congress. House Committee on Science and Astronautics. The Panel on Science and Technology. Management of information and knowledge. A Compilation of papers prepared for the eleventh meeting of the Panel on Science and Technology. Washington, U.S. Govt. Print. Off., 1970. 130 p.
T174.5 .P3

<u>1971</u>

U.S. Congress. House. Committee on Education and Labor. Select Subcommittee on Education. To establish a National Institute of Education. Hearings, 92d Congress, 1st session. Washington, U.S. Govt. Print. Off., 1971. 705 p.
Hearings held in Washington Feb. 18, 24; March 17, 23; May 11, 17, 1971; New York, N.Y. March 20, 1971 and Chicago, June 14, 1971.
KF 27 .E335 1971b

U.S. Congress. House. Committee on Science and Astronautics. Subcommittee on Science, Research, and Development. New technology in education. Selected references. Committee Print, 92d Congress, 1st session. Washington, U.S. Govt. Print. Off., 1971. 140 p.
Z5814. V8 U48

1972

U.S. Congress. House. Committee on Education and Labor. Select Subcommittee on Education. Educational technology. Hearings, 92d Congress, 2d session, on H.R. 4916. Washington, U.S. Govt. Print. Off., 1972. 368 p.
Hearings held May 5, 1971 and Sept. 13, 1972.
KF 27 .E335 1972 c

U.S. Congress. House. Committee on Appropriations. Subcommittee of the Committee on Appropriations. Departments of Labor and Health, Education, and Welfare and Related Agencies. Appropriations for fiscal year 1973. Hearings, 92d Congress, 2d session, on H.R. 15417. Washington, U.S. Govt. Print. Off., 1972. Part 1, 1302 p. Part 2, 6971 p.
Hearings held May 25, 1972.
KF 26 .A6 1972 h

1973

U.S. Congress. Senate. Committee on Labor and Public Welfare. Subcommittee on Handicapped. Education of the handicapped. Hearings, 93rd Congress, 1st session, on S. 896 and others. Washington, U.S. Govt. Print. Off., 1973. 694 p.
Hearings held March 20, 21, and 23, 1973. KF 26 .L3515 1973

1975

U.S. Congress. House. Committee on Interstate and Foreign Commerce. Subcommittee on Communications. Telecommunications facilities and demonstration act of 1975. Hearings, 94th Congress, 1st session, on H.R. 4564. Washington, U.S. Govt. Print. Off., 1975. 146 p.
Hearings held June 3 and 4, 1975. KF 27 .I5537 1975c

1976

U.S. Congress. Office of Technology Assessment. The Feasibility and value of broadband communications in rural areas. Washington, (Office of Technology Assesment), 1976. Various pagings. LRS76-11030

1977

U.S. Congress. Senate. Committee on Commerce, Science, and Transportation. Subcommittee on Communications. Rural telecommunications. Hearing, 95th Congress, 1st session on oversight of rural telecommunications. Washington, U.S. Govt. Print. Off., 1977. 138 p.
Hearing held on Apr. 26, 1977. KF 26 .C6925 1977

U.S. Congress. Committee on Science and Technology. Subcommittee on Domestic and International Scientific Planning, Analysis, and Cooperation. Computers and the learning society. Hearings, 95th Congress, 1st session. Washington, U.S. Govt. Print. Off., 1977. 697 p.
Hearings held Oct. 4, 6, 12, 13, 18, and 27, 1977.
KF27 .S3927 1977h

1978

U.S. Congress. Senate. Committee on Commerce, Science, and Transportation. Communications and rural America. Committee Print, 95th Congress, 1st session. Washington, U.S. Govt. Print. Off., 1978. 49 p. HE 7781 .M53

U.S. Congress. House. Committee on Government Operations. Subcommittee on Government Activities and Transportation. Federal audiovisual materials policy and programs. Hearings, 96th Congress, 1st session, also on H.R. 9657, the Federal Audiovisual Materials Act of 1977. Washington, U.S. Govt. Print. Off., 1978. 609 p.
Hearings held in Washington Sept. 21 and Oct. 26 in Los Angeles, 1978.
KF 27 .G6626 1978h

U.S. Congress. House. Committee on Science and Technology. Subcommittee on Domestic and International Scientific Planning, Analysis, and Cooperation. Computers and the learning society. Committee Print, 95th Congress, 2nd session. Washington, U.S. Govt. Print. Off, 1978. 48 p.
LB 1028.5 .U52 1978

1979

U.S. Congress. Senate. Committee on Appropriations. Subcommittee on Labor and HEW Appropriations. Departments of Labor, and Health, Education, Welfare and Related Agencies, appropriations, FY80. Hearings, 96th Congress, 1st session. Washington, U.S. Govt. Print. Off., 1979. 797 p.
Hearings held Mar. 12-15, 1979.

U.S. Congress. House. Committee on Appropriations. Subcommittee on Labor and HEW Appropriations. Departments of Labor, Health, Education, and Welfare, Appropriations for 1980. Part 5: Department of Health, Education and Welfare; Education. Hearings, 96th Congress, 1st session. Washington, U.S. Govt. Print. Off., 1979. 1135 p.
Hearings held Mar., 22, 23, 26-29, 1979.

U.S. Congress. House. Committee on Education and Labor. Subcommittee on Elementary, Secondary, and Vocational Education. Foresight hearings on future trends in elementary and secondary education. Hearings, 96th Congress, 1st session. Washington, U.S. Govt. Print. Off., 1979. 213 p.
Hearings held Apr. 25, 26, 1979.
KF 27 .E3364 1979j

U.S. Congress. House. Committee on Education and Labor. Subcommittee on Elementary, Secondary, and Vocational Education. Oversight hearing on vocational education. Hearing, 96th Congress, 1st session. Washington, U.S. Govt. Print. Off., 1979. 236 p.
Hearing held Mar. 1, 1979. KF 27 .E3364 1979b

U.S. Congress. House. Committee on Education and Labor. Amending Title 1 of the Elementary and Secondary Education Act of 1965. Committee Report, 96th Congress, 1st session. Washington, U.S. govt. Print. Off., 1979. 52 p.

U.S. Congress. House. Committee on the Judiciary. Subcommittee on Courts, Civil Liberties, and the Administration of Justice. Off-air taping for educational use. Hearings, 96th Congress, 1st session. Washington, U.S. Govt. Print. Off., 1979. 189 p.
Hearing held Mar. 2, 1979. KF 27 .J857 1979d

U.S. Congress. House. Committee on Science and Technology. Subcommittee on Science, Research and Technology. Information and communications technologies appropriate in education (including H.R. 4326). Hearings, 96th Congress, 1st session. Washington, US. Govt. Print. Off., 1979. 250 p.
Hearing held October 9, 1979. KF 27 .S399 1979h

1980

U.S. Congress. Joint Hearings. House Committee on Science and Technology. Subcommittee on Science, Research, and Technology and House Committee on Education and Labor. Subcommittee on Select Education. Information technology in education: Joint Hearings and Workshop. Washington, U.S. Govt. Print. Off, 1980. 250p.

U.S. Congress. Joint Report. Committee on Science and Technology. Subcommittee on Science, Research, and Technology and Senate Committee on Labor and Human Resources. Subcommittee on the Handicapped. Application of technology to handicapped individuals: Process, problems, and progress. Joint Committee Print, 96th Congress, 2nd session. Washington, U.S. Govt. Print. Off., 1980. 317 p. RD 755 .U56 1980

U.S. Congress. Senate. Committee on Labor and Human Resources. Subcommittee on Education, Arts, and Humanities. International Information Exchange: Relevant Activities of the White House Conference on Library and Information Services. Washington, U.S. Govt. Print. Off, 1980. 156 p.

U.S. Congress. House. Committee on Education and Labor. Subcommittee on Elementary, Secondary, and Vocational Education. Needs of elementary and secondary education in the 1980's. A Compendium of policy papers. Committee Print, 96th Congress, 2nd session. Washington, U.S. Govt. Print. Off., 1980. 693 p.

NON-LEGISLATIVE BRANCH PUBLICATIONS

Ackerman, Jarrold, and Lawrence Lipsitz, eds. Instructional television: status and direction. Englewood Cliffs, N.J., Educational Technology Publications, 1977. 217 p. LB 1044 .7 .I492

Armsey, James W., and Norman C. Dahl. An inquiry into the uses of instructional technology. A Ford Foundation report. [New York, The Ford Foundation, 1973] 113 p. LB 1028 .3 .A767 1979

Association for educational communications and technology. The Definition of educational technology. Washington, Association for Educational Technology, 1977. 169 p.

Association for Educational Communications and Technology. Educational technology: a glossary of terms. Washington, Association for Educational Technology, 1979. 371 p.

Baker, Frank B. Computer managed instruction. Englewood Cliffs, New Jersey, Educational Technology Publications, 1978. 417 p. LB 1028 .46 .B23

Berry, Dorothea M. A bibliographic guide to educational research. Metuchen N.J., Scarecrow Press, 19/5. 150 p. Z5811. B39

Brown, George W. and others. EDUNET. Report of the summer study on information networks. New York, John Wiley and Sons, 1967. 440 p.

Brown, Les. Keeping your eye on television. New York, Pilgrim Press, 1979. 84 p. HE 8700 .8 .B748

Caffrey, John and Charles J. Mosmann. Computers on campus. Washington, American Council on Education, 1967. 207 p. LB 2341 .C13

Cantwell, Zita M. and Doyle, Hortense A. Instructional technology: an annotated bibliography. Methucen, N.J., Scarecrow Press, 1974. 387 p. Z5814 .A85 C35

The Carnegie Commission on Higher Education. The Fourth revolution in higher education. New York, McGraw Hill, 1972. 106 p. LB1028 .3 .C3

The Carnegie Commission on the Future of Public Broadcasting. A Public trust. New York, Bantam Books, 1979. 401 p. HE 8700 .8 .C37

Chadwick, Clifton B. Why educational technology is failing (and what should be done to create success). Educational technology, v. 19, Jan. 1979: 7-19.

Chartrand, Robert Lee and James W. Morentz Jr. Ed. Information Technology Serving Society. New York, Pergamon Press, 1979. 150 p. Z699 .I4733 1979

Cleary, Alan. and others. Educational technology: Implications for early and special education. New York, John Wiley & Sons, 1976. 191 p.
LB 1028 .3 .C62

Computer Assisted instruction: The Best of ERIC. Matian Beard. ed. ERIC clearinghouse on information resources, Stanford, California, 1976. 38 p. LB 1028 .5 .D3

Conant, Eaton H. Teacher and paraprofessional work productivity. Lexington, Mass., Lexington Heath, 1973, 149 p.

Christiansen, J.E. Worksampling; A Stroboscopic view. Educational Administration and Supervision, v. 42, Apr. 1956. p. 230-243.

Darby, Charles A. Jr. and others. The Computer in secondary schools. A survey of its instructional and administrative usage. New York, Praeger Publishers, 1972. 135 p. LB 1028 .5 .D3

Doerr, Christina. Microcomputers and the 3 r's. A guide for teachers. Rochelle Park, New Jersey, Hayden Book Company, 1979. 177 p.
LB 1028 .5 .D63

Duggan, Michael A. and others, ed. The Computer Utility: Implications for higher education. Lexington, Massachusetts, Heath Lexington Books, 1970. 294 p. LB 2341 .586 1969

Edwards, Judith, et. al. Computer applications in instruction: a teacher's guide to selection and use. Hanover, N.H., TimeShare (A Houghton Mifflin Company) [1978] 202 p. LB 1028 .5 .N58 1978

Ellis, Allan B. The use and misuse of computers in education. New York, McGraw Hill Book Company, 1974. 226 p. LB 1028 .3 .E44

Encyclopedia of Education. Lee C. Deighton ed. New York, Macmillan, 1971, 10 v. LB15 .B56 1970

The Ford Foundation. An Inquiry into the uses of instructional technology. New York, The Ford Foundation, 1973. 113 p. LB 1028 .3 .A75

Goodlad, John I. and others. Computers and Information Systems in Education. New York, Harcourt, Brace & World, 1966. 152 p.
LB 1028 .5 .G64

Gordon, William A. Communications satellites and the future of elementary education. World Future Society bulletin, v. 12, May-June 1978.

Hamblen, John W. Inventory of computers in U.S. higher education 1966-1970. Washington, U.S. Govt. Print. Off., 1972. Various pagings.
QA 76 .H27

Hamblen, John W. Computers in higher education. Fourth inventory of computers in U.S. higher education. 1976-1977. Princeton, EDUCOM, 1979. Various pagings. QA 76 .27 .H35

Harris, Diana, ed. Proceedings of the National Education Computing Conference 1979. Iowa City, Iowa, University of Iowa, 1979. 388 p.

Hartnett, Rodney T. and others. The British Open University in the United States. Princeton, Educational Testing Service, 1974. Various pagings. LC 6576 .B74

Heinich, Robert. Technology and the management of instruction. Washington, Association for Educational Communications and Technology, 1970. 198 p.

Hooper, Richard and Ingrid Toye eds. Computer Assisted Learning in the United Kingdom. Huddersfield, Great Britain, H. Charlesworth & Co. Ltd. 1975. 350 p.
LB 1028 .5 .C533

Hsiao, T.C. Who's Who in Computer Education and Research. Washington, Science and Technology Press, 1975. 312 p. OA 76 .27 .W46

Hunter, Beverly, et. al. Learning alternatives in U.S. education: where student and computer meet. Englewood Cliffs, N.J., Educational Technology Publications [1975] 398 p.

Into the Information Age: a perspective for Federal action. Arthur D. Little. Chicago, American Library Association, 1978. 134 p.
T10.63.A1 L57

Jamison, Dean T. and Stevan J. Klees, Stuart J. Wells. The Costs of Educational Media. Beverly Hills, Sage Publications, Inc., 1978. 255 p. LB 1028 .3 .J5

Levien, Roger E. et. al. The Emerging technology: instructional uses of the computer in higher education. A Carnegie Commission on Higher Education and Rand corporation study. New York, McGraw-Hill Book Co. [1972] 585 p. LB 1028 .5 .L49

Lewis, R. and E.D. Tagg. Computer Assisted Learning. Scope, Progress, and Learning. New York, North-Holland Publishing Company, 1980. 223 p. LB 1028 .5 .I14

Proceedings of the IFIP TC3 Working Conference on Computer Assisted Learning-Scope, Progress and Limits. Roehampton, England 3-7 September 1979.

Loughary, John W. and others. Man-machine systems in education. New York, Harper & Row, 1966. 242 p. LB 1028 .L65

Lucas, William A., Karen A. Heald, and Judith S. Bazemore. The Spartanburg interactive cable experiments in home education. A report prepared for the National Science Foundation. Santa Monica, CA., Rand, 1979. 153 p. A S36 .R3 R-2271

Margolin, Joseph B. and Marion R. Misch. Computers in the classroom. An interdisciplinary view o' trends and alternatives. New York, Spartan Books, 1970. 382 p. LB 2341 .M65

Microcomputers in education: special issue. Educational technology, v. 19, Oct. 1979: whole issue.

Miller, George A. Automated dictionaries, reading and writing. Chairmans' report of a conference on educational uses of word processors with dictionaries. Washington, National Institute of Education, 1979. 29 p.

Mitre Corporation. Definition of a planning and design study for a national center for educational technology. Washington, Mitre Corporation, 1968. 60 p.

Molnar, Andrew R. Computer innovations in education. Columbus, OH., ERIC Information analysis Center for Science, Mathematics and Environmental Education, Ohio State University, 1973. 91 p.

Molnar, Andrew R. National policy toward technological innovation and academic computing. Journal of technological horizons in education, v. 4, Sept. 1977: 39-43. LB 1028 .M55

Morphet, Edgar L. and David L. Jesser. Designing education for the future. Planning for effec ive utilization of technology in education. New York, Citation Press, 1969. 372 p.

Mosman, Charles. Academic computers in service. San Francisco, Jossey-Bass, 1973. 186 p. LB 2341 .M65 1963

Mosmann, Charles. Evaluating instructional computing. Measuring needs and resources f · computing in higher education. Irvine, California, University of California, 1976. 88 p. LB 1028 .5 .M67

Mulkowsky, Gary P., and Michael Freeman. Implementing educational technology: must the future repeat itself? World Future Society bulletin, v. 13, Jan.-Feb. 1979: 33-36

National Educational Computing Conference. Proceedings of the NECC 1979. Iowa City, Iowa, The University of Iowa, 1979. 388 p.

Oettinger, Anthony G. Run, Computer, Run. The Mythology of educational innovation. Cambridge, Mass., Harvard University Press, 1970. 302p. LB 1027 .O32

Rothman, Stanley and Charles Mosmann. Computers and society. The technology and its social implications. Chicago, Science Research Associates, 1976. 423 p. QA 76.9. C66 R67 1976

Saettler, Paul. A history of instructional technology. New York, McGraw Hill, 1968. 399 p. LB 885 .S15

Seidel, Robert J., and Martin Rubin, eds. Computers and communications: implications for education. New York, Academic Press, Inc., 1977. 409 p.

Sleeman, Philip J. and D.M. Rockwell ed. Instructional media and technology A professional's resource. Stroudsberg, Pennsylvania, Halstead Press, 1976. 401 p. LB 1028 .3 .I55

Sleeman, Phillip J. and others. Instructional media and technology. A guide to accountable learning systems. New York, Longman, 1979. 374 p. LB 1028 .3 .S57

Suppes, Patrick and others. Computer-Assisted Instruction at Stanford, 1966-68: Data, Models, and Evaluation of the Arithmetic Programs. New York, Academic Press, 1972. 533 p. QA 20 .P7S92 1972

Technology in Science Education; The Next Ten Years. National Science Foundation. Washington, National Science Foundation, 1979. 37 p.

Tucker, Richard N. The organizational management of educational technology. London, Crom Helm, 1979. 167 p. LB 1028 .3 .T82

U.S. National Science Foundation. Directorate for Science Education. Technology in science education: the next ten years-perspectives and recommendations. Washington, National Science Foundation, 1979. 37 p.

Pilnick, Carl and Harry R. Glixon. Telecommunications in Education. A Planning document for the establishment of a nationwide educational telecommunications system. Washington, Synergetics Inc., 1972. Various pagings. QA 76 .9 .C66R67

Proceedings of the National Conference on Professional Development and Educational Technology. January 16-18, 1980, Washington D.C. Information Dynamics, Inc., 1980. 168 p.

Rockart, John Fralick, and Michael S. Scott Morton. Computers and the learning process in higher education. A report prepared for the Carnegie Commission on Higher Education. New York, McGraw-Hill Book Co. [1975] 356 p.

U.S. National Academy of Engineering. Commission on Education. Advisory Committee on Issues in Educational Technology. To realize the promise: issues and public policies in educational technology. Washington, National Academy of Engineering, 1973. 107 p.

U.S. President's Science Advisory Committee. Computers in higher education. Washington, U.S. Govt. Print. Off., 1967. 67 p.

Wanger, Judith. Education and training for online systems. In: Williams, Martha E., ed. Annual review of information science and technology. v. 14. [White Plains, N.Y.] Knowledge Industry Publications, 1979: 219-245.

Wood, Donald N., and Donald G. Wylie. Educational telecommunications. Belmont, Ca., Wadworth Publishing Co., 1977. 370 p.

Wood, Fred and others. Videoconferencing via satellite: Opening Congress to the people. Washington, George Washington University, 1979. 66 p.

APPENDIX 17

List of Participants: October 1979 Hearing 1/

Dr. Lewis Branscomb, chief scientist and vice president for research, IBM Corp. ...

Dr. Delbert D. Smith, attorney at law, Madison, Wis. ...

Robert G. Gillespie, vice provost for computing, University of Washington

National Science Foundation panel:

- Dr. F. James Rutherford, Assistant Director for Science Education and Dr. Andrew R. Molnar, Program Manager, Research in Science Education, Directorate for Science Education ...
- Dr. Judith Edwards, Northwest Regional Educational Laboratory, Portland, Oreg ...
- Prof. Robert Hornik, Annenberg School of Communications, University of Pennsylvania ...

"Grass Roots" user panel:

- Dr. Allen S. Lefohn, chairman, Western Information Network on Energy, Helena, Mont ...
- Prof. Mitsuru Kataoka, Dickson Art Center Video Laboratory, University of California, Los Angeles; and Mr. A. Stanley Corey, superintendent, Irvine Unified School District, Irvine, Calif ...
- Dr. Nellouise Watkins, director, Computer Center, Bennett College Greensboro, N.C. ...
- Ms. Colleen Cayton, development officer, Denver Public Library ...
- Edward Zimmerman, Deputy Assistant Secretary of Commerce for Communications and Information, and Deputy Administrator of the National Telecommunications and Information Administration; accompanied by Ms. Kathleen Criner, program manager, Information Technology Program, NTIA ...

1/ U.S. Congress. House. Committee on Science and Technology. Subcommittee on Science, Research, and Technology. Information and Communications Technologies Appropriate in Education (including H.R. 4326). Hearing, 96th Congress, 1st session. Oct. 9, 1979. Washington, U.S. Govt. Print. Off., 1979 p. III.

APPENDIX 18

List of Participants: April 1980 Joint Hearing 1/

April 2, 1980:
- Arthur S. Melmed, advisor to the director, National Institute of Education
- Dr. Dustin Heuston, chairman, World Institute for Computer Assisted Teaching (WICAT)
- Dr. J. C. R. Licklider, Laboratory for Computer Science, Massachusetts Institute of Technology
- Dr. Maxine Rockoff, vice president, planning and research, Corporation of Public Broadcasting
- Dr. Vivian Horner, vice president, program development, Warner Cable Corporation
- Dr. James Johnson, director, academic computing, University of Iowa

April 3, 1980:
- Dr. Charles Mosmann, associate vice president, Academic Resource planning, California State University, Fullerton, Calif.
- Ernest J. Anastasio, assistant vice president for research and development administration, Educational Testing Service

1/ U.S. Congress. House. Committee on Science and Technology, Subcommittee on Science, Research, and Technology, and the Committee on Education and Labor, Subcommittee on Select Education. Information Technology in Education. Hearings, 96th Congress, 2nd session. April 2, 3, 1980. Washington, U.S. Govt. Print. Off., 1980. P.V.

APPENDIX 19

LIST OF RESEARCH PROGRAMS, ORGANIZATIONS, AND INDIVIDUALS WORKING WITH EDUCATIONAL TECHNOLOGY 1/

ABC/NEA SCHOOLDISC Program
Fred Wilhelms
Teachers develop ideas for videodisc and TV people implement them.

Robert Albrecht
Menlo Park, California - "Computer Town, USA.

Barry Anderson
Washington University
The more kids watch Sesame Street, the more they learn
Disadvantaged children are no more helped by Sesame Street than advantaged ones.

J. Andriessen
Phillips Research Laboratories
Medical students liked a trial videodisc course more than slides or film

Dwight Allen
Old Dominion University, Norfolk, Virginia
The new "basics"; learning to use the tools of our time to improve the quality of life. No teacher will complain about having extra moments to read a story with his students while the computer grades a quiz. Government must guarantee technologies for the poor as well as the rich. There is a need for national coordination of accreditation and curricula in a mobil decentralized age induced by technologies.

Berks Community Television (BCTV)
Reading Pennsylvania
Gerald Richter, Executive Director
Interactive community television
TV of, for and by the people.
Open forums on issues, with phone-ins, split-screen.
Students interview about history, produce own shows.

Karen Billings
Columbia University. Helping educators use microcomputers.

Alfred Bork
University of California, Irvine
Physics by computer tutorial
The future: stand-alone systems, graphics, videodiscs.

1/ Based on a study performed for the Horace Mann Learning Center of the U.S. Department of Education by the International Center for Integrative Studies entitled: Towards More Effective Teaching and Learning: New Directions for Educational Technologies in the 1980's: Research and Studies.

William Bozeman
University of Iowa
Reviewing studies of Computer Managed Instruction, concludes
CMI is effective.

Robert Branson
Florida State University
Calls for user groups to tell videodisc manufacturers what they want.

Ludwig Braun
Stony Brook, New York
Huntington Project - developed 24 simulations, used them in schools.
Microcomputer advocate.
Proposing national centers of R & D for micros in schools.

Brigham Young University. Computer Teaching Research Center.

Red Burns
Director, Alternative Media Center, New York University,
which started BCTV.
Members, Carnegie Commission on Educational Television, which
recommended reorganizing public braodcasting in A Public Trust

Catholic University of America. Center for Educational Technology.
Graduate School for Education. Dr Joseph A. Tucker, Director.

Sylvia Charp
Instructional Systems, Philadelphia public schools.
Long experience with computers in schools. Kids and
parents learn together by computer.

Peggy Charren
President, Action for Children's Television
Newtonville, Massachusetts
Promotes diversity and discourages commercial abuse.

Richard Clark
Center for Media Research and Development
University of Southern California, Los Angeles
Bridges the gap between research and the application of
educational technology.

CONDUIT
University of Iowa
Jim Johnson, Harold Peters
Clearinghouse for courseware for college CAI
Helps authors of courseware.
Researching educational effectiveness of graphics and audio.

Christopher Dede
President, Education Section, World Future society
The costs of conventional education will increase, while the
costs of computers in education will decrease.

Stewart Denenberg
State University of New York, Plattsburgh
A PLATO course for computer literacy
costs of computers in education will decrease.

Peter Dirr
Corporation for Public Broadcasting
Fifteen million American pupils a year use instructional TV somewhat regularly.
Sixty percent of colleges use ITV, especially community colleges.

Christine Doerr
Microcomputer and the Three R's - "how to" for teachers

Tom Dwyer
Project SOLO, University of Pennsylvania. Helping students learn to use computers "SOLO" under their own control.

Lester Eastwood
Washington University
Intelligent videodisc, although appealing, faces major barriers like teacher resistance, tight budgets and lack of courseware.

Judy Edwards
Computer Technology Program, Northwest Regional Educational Laboratory
MicroSIFT: Clearinghouse of microcomputer materials for K-12 teachers.

Charles Ferris
Chairman, Federal Communications Commission
Children's programming has changed little in the last six years.
The technologies can transmit a much greater abundance of diverse programming.

John Fielden
The Costs of Learning with Computers, an analysis of the NDPCAL,

Raymond Fox
Society for Applied Learning Technology (SALT), Virginia Conference on videodisc

Lawrence T. Frase
Bell Laboratories
A thorough review of theory and research in "educational technology" defined as science applied to educational practice. This review gives a backdrop to our survey of uses of hardware.

Robert Gagne
Educational Research, Florida State University
Internationally known for relating hierarchical learning theory to instructional technology, as he did in Principles of Instructional Design (1979). Gagne sees educational technology lagging behind research's prescriptions that materials (1) make semantic encoding possible by providing larger meaningful contexts and (2) help learners realize their capacity for "metacognition," for learning how to learn.

George Washington University. Clearinghouse for Higher Education. Washington D.C. Peter R. Muirhead, Director.

Charles Goldstein
Development of the ATS computer based educational technology system at the Lister Hill Center of the National Library of Medicine.

John Haugo
Director, Minnesota Educational Computing Consortium (MECC)
The largest educational computing network in the world.
Almost every school and college in the state uses computers.
MECC coordinates and supports.

Jacques Hebenstreit
Ecole Superieure d'Electricite
10,000 Microcomputers in French Secondary Schools

Howard Hitchens
Executive Director
Association for Educational Communications and Technology (AECT), Washington.
Has overview of development of audiovisual instruction.
AECT will be publishing a book this fall on media for education by Eugene Wilkenson of the University of Georgia

Horace Mann Learning Center. U.S. Department of Education. Grace Watson Chief.

Indiana University. Instructional Services Center. School of Education. Dr. Nicholas Anasiow.

International Institutes for Educational Technology. Arlington, Virginia. Dr. Gabriel D. Ofiesh, President.

Dean Jamison
Economist, The World Bank
The Costs of Educational Media: Guidelines for Planning and Evaluation
Per-student hour costs for radio: 1 - 5 cents; for ITV: 5 - 15 cents
Cost analysis is complicated and approximate.

Linda Kahn
Director of Curriculum Development
Prime-Time School Television (PTST)
Chicago, Illinois
700,000 teachers use PTST teacher guides for curricula based on TV programs like Roots and ABC Evening News.

Robert Lawler
LOGO Group, Artificial Intelligence Lab, Massachusetts Institute of Technology. A six-year-old learns to write, and more, in a computer-rich setting.

Kit Laybourne
Director, Media Probes, New York
Doing TV series to help people understand TV.
Promotes people-produced TV.

John LeBaron
Massachusetts Educational TV
Director, Planning and Development
Television by Children: A Production Guide for Young

Joseph Lipson
Science Education, National Science Foundation
Need aesthetic and emotional qualities in CAI

Arthur Luehrmann
Lawrence Hall of Science, Berkeley
Bussing bushels of Apples (microcomputers) to schools.
The U.S. future depends on computer literates, doers with computers.

Andrew Molnar
National Science Foundation, Research in Science Education
The next crisis in American education - computer literacy
Computer and videodisc - intelligent videodisc for science education.

David Moursund
University of Oregon
Editor, The Computing Teacher

National Audiovisual Center, part of the National Archives in Washington D.C. Collects for sale and rental all audiovisual materials (slides, videocassettes, and film) produced for and by the Federal government.

National Educational Association, Research Department. Washington D.C.
Jean M. Flanigan. Director of Research.

National University Consortium Project
Dr. Adele Seef
University of Maryland
The first nationwide TV university begins September, 1980.
Courses lead to B.A.

Nebraska Videodisc Project
University of Nebraska, Lincoln
Rod Daynes, Director
Educational videodisc R & D
Teachers of tumbling loved using videodisc.
Use for the hearing impaired.

Nicholas Negroponte
Massachusetts Institute of Technology
Media room: multimedia, multisensory input and output under learner's control.
Imaginative uses of intelligent videodisc, map-travelling, making movies modular.

Ted Nelson
Computer Lib Dream Machine

Frank Norwood
Executive Director
Joint Council on Educational Telecommunications (JCET), Washington, D.C.
Educators must help form national communications policy.
JCET assists this with studies and forums.
Some forums have used teleconferencing by satellite at modest cost.
JCET offers to help the Department of Education to explore conferencing for the kinds of public dialogues Tyler urges above.

Seymour Papert
LOGO Project, MIT
Kids teach procedures to turtle robot. Learning math without teaching, in mathland. Cognitive growth may be different in a computer culture.

Howard Peelle
Instructional Application of Computers, University of Massachusetts
Glass box approach - lets the student view the program he is using, removing mystery, providing models.

Pennsylvania State University. Computer-Assisted Instruction Laboratory.
Dr. Keith A. Hall, Director.

PLATO
Donald Bitzer, its father, University of Illinois, champaign/Urbana
Robert Caldwell, Southern Methodist University, says his PLATO reading program helps adult nonreaders.
Spencer Swinton of Educational Testing Service (ETS) found elementary PLATO math effective, reading not, and PLATO too expensive.
Richard Murphy of ETS found PLATO project for community colleges made no difference in achievement.
Howard Mark of Control Data Corporation is hooking color PLATO to videodisc.

Rosemary Lee Potter
New Season: The Positive Use of Commercial Television with Children, 1976 Classroom activities using prime-time TV to teach thinking skills.

Neil Postman
Teaching as a Conserving Activity, 1979
TV is today's "first curriculum" for children; school the second, and schools should thermostatically balance the first with word-centered content.

QUBE
Columbus, Ohio
Vivian Horner, educational programming
Gerry Jordon, program development
Cable TV viewers may push one of five buttons to polling by the studio

Saul Rockman
Director, Agency for Instructional Television, Bloomington, Indiana
Coordinates joint program projects by state and provincial agencies.
Acquires and distributes ITV programs.

Nicholas J. Rushby
Computers in Education as a Resource, Ingersoll College
United Kingdom National Development Programme
in Computer-Assisted Learning (NDPCAL)

William Rushton
Center for Non-Broadcast Television, New York
Director of Research
Viewer participation on timely topics via public television and cable.

Gavriel Salomon
Hebrew University of Jerusalem
A leading theorist about media.
Interaction of Media, Cognition and Learning, 1979
Explores the ways a learning task is affected by the degree of fit between the symbol systems of the medium and a learner's symbolic representations.

Wilbur Schramm
East-West Communication Institute, Honolulu, Hawaii
Educator, philosopher and writer on issues about communication and media.

Robert Seidel
Human Resources Research Organization (HumRRO), Arlington, Va.
Computer simulations give unique learning, quickly.

Sesame Place
Lower Bucks County, Pennsylvania
A playpark for kids, by Children's Television Workshop and Busch Entertainment.
Seventy computers designed for kids with educational games that are fun to play.
Joan Ganz Cooney, President, CTW
Joyce Hakansson, Computer Coordinator
Marilyn Rothenberg, Research

Dorothy and Jerome Singer
Family Television Research and Consultation Center
Yale University
Helping children view TV critically
Materials for parents and teachers.

Dorothy Jo Stevens
University of Nebraska
Teachers have mixed feelings about computers, but think computers should be taught.

Patrick Suppes
Stanford University. CAI in logic, set theory and languages;
Research on speech synthesis
Computer Curriculum corporation:
Large scale use of basic skills drill-and-practice.
The future: talking dialogues between students and
computer tutors.

David Thomas
University of Iowa
Surveyed evaluations of CAI - it's quicker.

Ralph Tyler
Science Research Associates, Chicago, Illinois
This eminent educator puts our discussion in perspective.
Educational technologies need to be guided by an understanding of
schools, of what teaching is and is not, of why teachers do and
do not adopt technologies.
Teachers and technologists must develop programs together.
The Secretary of Education should lead a widespread and informed
dialogue on educational issues.

University of Illinois. Computer-Based Education Laboratory. Dr Donald
L. Bitzer, Director.

University of Mid-America
Lincoln, Nebraska
Donald McNeil, Executive Vice President
Develops and distributes ITV for eleven states.

University of Texas. Computer-Asisted Instruction Laboratory. Austin,
Texas. Wilson A. Judd and Harold F. O'Neil co-directors.

Peter Wagshal
Director, Future Studies Program, University of Massachusetts
Spoken input and output of future technologies will make reading
a much less important skill, and education should prepare now for the change.

WICAT
Orem, Utah
Dustin Heuston
Victor Bunderston (Mr. TICCIT)
Educational systems are "mature", need new technology
to increase productivity. Intelligent videodisc is inevitable.

The Xerox Palo Alto Research Center
Allen Kay
John Seely-Brown
Iva Goldstein
Using the computer as an intelligent coach.

Karl Zinn
Center for Research on Learning and Teaching, University of Michigan
The multiple uses of micros in schools and colleges

APPENDIX 20

Glossary of Terms

The purpose of this glossary is to provide useful, succinct definitions of selected terms which concern information technology and its roles in education. The majority of these definitions originally appeared in The First Book of Information Science. 1/

Algorithm
A prescribed set of well-defined rules or processes for the solution of a problem in a finite number of steps.

Audiovisual materials
A collective noun (not the name of a field), referring to a collection of materials and devices which are displayed by visual projection and/or sound reproduction; sometimes used (albeit incorrectly) to designate a field of study.

Binary
1. The number representation system with a base of two. 2. A characteristic or property involving a selection, choice or condition in which there are only two possibilities.

Bit
A contraction of the term binary digit; it is the smallest unit used to represent information in a binary system.

Buffer
A temporary storage device used to compensate for a difference in the speed of data flow or the occurrence of events when data are being moved from one device to another.

"Bug"
A mistake in the design of a routine or a computer, or a malfunction.

Cable television
The reception of long distance television programs retransmitted to local TV sets over underground coaxial cables.

Character Recognition
The technique of reading, identifying, and encoding a printed character by optical means.

"Chip" (or integrated circuit)
A miniaturized electrical (or electronic) circuit assembly with certain of its components reduced to microscopic size. Such a device may be smaller than a thumbnail yet house the equivalent of hundreds of transistors, etc. The term "integrated" is used because the device's components are inseparable and formed on (or within) a continuous material. Integrated circuits have allowed the development of varying degrees of miniaturization in virtually all electronic audio and visual devices. Sometimes called a "chip."

1/ Becker, Joseph. The First Book of Information Science. Oak Ridge, Tennessee, USERDA-Technical Information Center, 1973. 90 p.

Communications
Electrical systems that can send and receive information messages.

Communications satellite
An earth-orbiting device capable of relaying communication signals over long distances.

Computer
An electronic machine capable of processing numbers and letters of the alphabet for many different purposes.

Computer-assisted instruction (CAI)
The use of a computer system to present an instructional program to an individual student and interpret his response. CAI requires the use of an on-line computer terminal and should be distinguished from computer-managed instruction.

Computer graphics
Digital creation of information displays.

Computer-managed instruction (CMI)
The use of the computer to help the teacher manage the educational process by assessing the student, suggesting a course of instruction, and monitoring his progress. To be distinguished from computer-assisted instruction.

Computer-output microfilm
The transfer of information from a computer to microfilm through an intermediate photographic device.

Computer program
A sequence of instructions that causes a computer to complete a desired task.

Core Storage
A form of magnetic storage that permits high-speed access to information within the computer.

Data banks
Large accumulated files of information in machine readable form for subsequent access by users via a computer.

Digitizer
A device which converts an analog measurement into digital form.

Disk Storage
A method of storing information in code, magnetically, in quickly accessible segments on flat, rotating disks.

Drum Storage
A method of storing information in code, magnetically, on the surface of a rotating cylinder.

Electronic message system (EMS)
Sometimes called electronic message services--a generic term used to describe computer-based message systems--electronic mail, for example.

Electronic printing
The coupling of information stored on a magnetic tape with high-speed photocomposition machines that automatically set type for printing.

Ergonomics
The design of effective man-machine systems. Ergonomics is usually concerned either with the design of furniture and other aspects of the environment to maximise human performance or with the design of displays.

Facsimile
The optical scanning of a page of printed or graphic information, its transmission over communication lines, and its faithful reproduction at a distant receiving location.

Ferrous Oxide
A special substance that is coated on magnetic tapes and disks. It contains iron particles that can be magnetized or demagnetized by a computer to represent binary information.

Fibre optics
Glass fibers which are used to carry optical impulses.

Floppy disk
A magnetic disk with a soft, flexible backing. Also called flexible disk. See also magnetic disk.

Hologram
A recording of information in three dimensions using a coherent light source

Information explosion
The exponential increase in the growth and diversification of all forms of information.

Information networks
The interconnection of a geographically dispersed group of libraries and information centers, through telecommunications, for the purpose of sharing their total information resources among more people.

Information science
The study of how man creates, uses, and communicates information in all forms.

Information system

A formal method by which information can be found, delivered, and used by those who need it.

Input

The process of entering information into a computer and especially into its memory.

Language laboratory

A special facility used particularly in the aural-oral method of language teaching; often each learner has a separate booth connected with a central station which can receive his/her speech, record it for him/her to play back, and also provide him/her other listening models of the language. (Also called learning laboratory.)

Language processing

The use of computer programs to manipulate words and ideas for functional purposes.

Laser

A tightly packed, narrow beam of light formed by the emission of high-energy molecules.

Libraries

Places where information of all kinds is stored, systematically organized, and made available for use on request.

Library Automation

Application of computers and other technology to library operations and services.

Library science

The study of the way libraries select, acquire, catalog, circulate, and make available books and other information.

Machine Language

A code used directly to operate a computer.

Machine readable

Information in a form such as punched holes or magnetic codes that can be processed directly by computers and other machines.

Machine translation

The use of computer programs to translate one language into another.

Magnetic disk

A ferrous oxide platter used for storing information in a way that makes it directly accessible for computer processing.

Magnetic Ink Character Recognition (MICR)

A method of storing information in characters printed with ink containing particles of magnetic material. The information can be detected or read at high speed by automatic devices.

Magnetic tape

A long strip of mylar plastic coated with ferrous oxide on which binary information may be stored, read, or erased.

Memory

An automated device that stores information for later recall.

Microfiche

A sheet of film that stores images of a reduced size in a grid pattern.

Microfilm

Photographic film used for recording graphic information in a reduced size.

Microcomputer

The term "microcomputer," which was first used to denote a subclass of minicomputers dedicated to single tasks and seldom if ever reprogrammed, has become a distinct category. Microcomputers are sometimes called "single chip LSI processors," "component processors," or "pico-computers," with no one term fully accepted. They are used as "stand alone" systems to provide added capabilities to standard computing installations and to enhance logical functions for noncomputer products, e.g., specialized television display, including videodisc. See also minicomputer.

Micrographics

The use of miniature photography to condense, store, and retrieve graphic information.

Microsecond

One millionth of a second.

Millisecond

One thousandth of a second.

Minicomputer

A small, powerful, usually rugged and comparatively inexpensive, general purpose computer. They are often subgrouped as mini-, midi, and maxi-computers according to the amount of storage they have (usually given in bytes), the number and kind of peripherals they use, and the price range. Minicomputers (all subgroups) usually have a more limited set of instructions than do larger computers. Instead of a fixed control section in the central processor, many minicomputers have programmable microprocessors which can be programmed for different applications. See also microcomputer.

Main frame
The portion of the computer which performs the calculations and decisions.

Magnetic cartridge
A storage container for magnetic storage media.

Network
1. In general, a system of interconnected points, agencies, organizations, or institutions which can distribute or interchange resources, energy, or information. 2. For broadcasting, a group of radio or television broadcasting stations connected by relays or coaxial cable so that all stations may broadcast a single program, originated at one point, simultaneously. 3. For information, a system of interconnected or related data banks or information sources from which data can be accessed (and sometimes stored) from a number of points; usually using electronic means. 4. For computers, two or more interconnected computers that perform local processing as well as transmit messages to one another and/or to a central computer for updating information and/or processing inquiries. 5. For libraries/learning resources centers, a formal organization among libraries and learning resources centers for cooperation and sharing resources usually with a hierarchical structure and subgroups.

On-line
The connection of a distant user terminal to a central computer through a continuing communication hook-up.

Optical Character Recognition (OCR)
The ability of a machine to scan a printed letter of the alphabet and discern which one it is.

Picture phone
A new device that permits you to see the person you are calling when making a telephone call.

Programming language
A special language supplied by a computer manufacturer for writing programs that cause the computer to function according to a programmer's instructions.

Programmed learning
A method of self-instruction achieved by a series of carefully designed items, which require responses from the learner and then provide information as to the accuracy of the response.

Publish
Putting an author's creative work into a form that can be distributed to many people.

Punched card
A stiff paper card of exact dimensions into which holes are punched to represent information. Subsequently, the information can be sensed and processed by mechanical, electrical, or optical machines.

Punched paper tape
A narrow strip of paper into which holes are punched to represent information for subsequent processing by machines.

Random Access
A technique for storing and retrieving data which does not require a strict sequential storage of the data nor a sequential search of an entire file to find a specific record. A record can be addressed and accessed directly at its location in the file.

"Read-write" head
A small electromagnet used for reading, recording, or erasing polarized spots, which represent information, on magnetic tape, disk or drum.

Real Time
The technique of computing while a process takes place so that results can be used to guide operation of the process.

Selective dissemination of information (SDI)
Computer selection and distribution of information to specific individuals based on their prestated subject interests.

Semiconductor chip
1. A solid or liquid electronic conductor, with resistivity between that of metals and that of insulators, in which the electrical charge carrier concentration increases with increasing temperature over some temperature range. Over most of the practical temperature range, the resistance has a negative temperature coefficient. Certain semiconductors possess two types of carriers: negative electrons and positive holes. The charge carriers are usually electrons, but there also may be some ionic conductivity. 2. An electronic device, the main functioning parts of which are made from semiconductor materials.

Software
1. The collection of man-written solutions and specific instructions needed to solve problems with a computer. 2. All documents needed to guide the operation of a computer, e.g., manuals, programs, flowcharts, etc.

Optical scanner
1. A device that scans optically and usually generates an analog or digital signal. 2. A device that optically scans printed or written data and generates their digital representations.

Telecommunications
A term pertaining to the communication by electric or electronic means and/or the transmission of signals over long distances, such as by telegraph, radio, or television. Telecommunications in a broader sense includes not only the technical aspects of transmission but also such aspects as the development of messages and programs and studies of audiences.

Television

A method of broadcasting information so that people see and hear it at the same time.

Terminal

A remote communications hookup to a computer that may be used for either input or output.

Time-sharing

Use of a central computer by many individuals in different locations at the same time.

Videodisc

A disc, usually plastic, on which are recorded video and/or audio signals for television use. A videodisc requires a videoplayer compatible with the videodisc.

APPENDIX 21

Acronyms for Key Organizations and Systems

ASIS	- American Society for Information Science
ARPANET	- Advanced Research Projects Agency Network
ADCIS	- Association for Development of Computer-based Instructional Systems
ARPA	- Advanced Research Projects Agency
AECT	- Association for Educational Communications and Technology
AID	- Agency for International Development
AT&T	- American Telephone and Telegraph Company
BLM	- Bureau of Land Management
CDC	- Control Data Corporation
CEDPA	- California Educational Data Processing Association
CIMS	- Comprehensive Instructional Management System
CBS	- Columbia Broadcasting System
CTBS	- California Test for Basic Skills
CPB	- Corporation for Public Broadcasting
DARPA	- Defense Advanced Research Projects Agency
DHEW	- Department of Health, Education and Welfare
DOA	- Department of Agriculture
EPA	- Environmental Protection Agency
EDUCOM	- Inter-University Communications Council
EOP	- Executive Office of the President
EDUNET	- EDUCOM Network
ERIC	- Educational Resources Information Center
GLODOM	- Global Domestic Satellite System
GNP	- Gross National Product
IBM	- International Business Machines Corporation
MEDLINE	- MEDLARS On-line
MIT	- Massachusetts Institute of Technology
NIMIS	- National Instructional Materials Information System
NEEDS	- New England Educational Data Systems
NTIA	- National Telecommunications and Information Administration
NBC	- National Broadcasting Company
NSF	- National Science Foundation
NIE	- National Institute for Education
NEA	- National Education Association
NASA	- National Aeronautics and Space Administration
NICEM	- National Information Center for Educational Media
NLM	- National Library of Medicine
OTA	- Office of Technology Assessment
OTP	- Office of Telecommunications Policy
TICCIT	- Time-shared, Interactive, Computer-Controlled Information Television
WHCLIS	- White House Conference on Library and Information Services
WINE	- Western Information Network on Energy
WICAT	- World Institute for Computer-Assisted Teaching

INDEX

A

77-352 O - 81 - 23

B

C

F

I

N

O

P

Q

R